June 27. 1825

A

SHORT INQUIRY

INTO THE

CAPILLARY CIRCULATION

OF THE

BLOOD;

WITH

A COMPARATIVE VIEW

OF THE

MORE INTIMATE NATURE

OF

INFLAMMATION:

AND AN

INTRODUCTORY ESSAY.

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"Cum haec per multa volumina, perque magnæ contentionis disputationes a medicis saepe tractata sint atque tractentur, subjiciendum est, quae proxima vero videri possint, ea neque addicta alterutri opinioni, neque sunt ab utraque nimium abhorrentia, media quodammodo inter diversas sententias quod in pluribus contentionibus deprehendere licet, sine ambitione verum scrutantibus, ut in hac ipsa re."

Celsus de Med. Lib. 1. Incip.

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PREFACE.

SO much has been written, and so ample have been the disquisitions, on the physiology of the whole circulation, and on the proximate nature of inflammatory action; that some notice may be deemed necessary, why the Author has entered on a field, where the investigations have already been as extensive, as the discoverers have been gifted and eminent. A very moderate acquaintance, however, with the state of medical science, will show, how varied and unsettled several opinions are, respecting some of the more intimate parts of physiology and pathology; so that, in wishing to arrive at something like scientific certainty, there is no little perplexity to be met with, in the study of the generally celebrated writings on these subjects. The desire of examining whether any thing of a more fixed and defined know-

ledge could be obtained,—with the primary view of giving more confidence to his own mind, was the first inducement with the Author to apply his leisure to some of those more important matters, wherein not a little indefiniteness and disagreement of opinion was perceived.

An exercise of this kind generally grows with what it feeds on; and finding that the deductions, to which it occasionally led, were, in some degree, different from those promulgated on the more general views of the subject, the Author was still further induced to arrange, as fully as the more practical vocations of his profession permitted, the limited extent of his experiments and the result of his observations, and to commit them to the press. That others will make the same deductions from the facts and observations advanced, as the Author has done in the following pages; or that they will be persuaded of these deductions being possessed of a superior theoretical interpretation of the economy of nature, it would be presumptuous in him to say; but if they shall afford an auxiliary elucidation to the researches of those who have so eminently and more amply preceded him in the same department of science, and in similar views of the

animal economy, or shall assist, in any measure, the inquirer in his investigations of the important doctrines at issue, the aim of this publication will be accomplished.

The writings of more authors might have been noticed, on some of the correlative subjects treated of; but as the object was physiological principles, an historical and literary attempt to discuss the several points, was as unnecessary, as it must have fallen short of what has been so extensively and repeatedly published to the profession.

The Author has chiefly to regret, in common with others, that the nature of the subject, and the data which they afford, are at times of so limited and refined a character; but he hopes it will be found, that the conclusions bear the only legitimate construction which the more exact sciences and the laws of animal life afford; and he can only say, that they are strongly confirmed by the better parts of practice, which he has witnessed, under very different circumstances of climate, and of men's occupations, habits, and constitutions.

Bolton, September, 1825.

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THE practice of medicine, though borne along with the general tide of improvement, which the arts and sciences have so remarkably experienced, may still be said, to be, in some degree, cultivated by the two different sects, which distinguished its history, in the days of Heraclides and Asclepiades. The elementary studies of the followers of the profession, in modern times, may have done much to instil and promote a uniform principle of thinking, and to obliterate the public distinctions of empiric and theorist; yet the respective and avowed principles, that guided the ancients, will still be found to have a subdued, but a prevailing influence on the minds of the great mass of practitioners. What has also tended to keep the distinctions permanent, is the pride of intellect and the mere "rerum naturæ contemplatio" contending with the successful blunders of the illiterate and uniniti-

ated, and the whole reveries of a painful life of study sometimes becoming eclipsed in usefulness, by the communication of a savage, or an accidental discovery in the brute creation. The Baconian philosophy, however, seemed destined to secure to the science of medicine that foundation, which it has so proudly established for the sister exercises of the understanding; and while its first appearance gave a death-blow to Paracelsian Theosophism, it left full play to all the reasoning powers, and quenched not the fires of genius, by inculcating a rigorous attention to fact and experiment.

It is, however, a source of much satisfaction to the mind of pure philosophy, that, notwithstanding the accidental or the obscure origin of many of the useful and decorative discoveries in the arts and sciences, the extensive application of many of them is entirely indebted to the ratiocinative powers of man, without which, the discovery would have been of limited utility, or merely looked upon as a puzzle or a wonder. The rational theorist, in the profession, has no less cause to exult in the successful generalization of accidental discovery and limited facts. The theory of the circulation in health and disease, and the exhibition of mercury and of several medicines in modern times, with the cow-pox, are splendid illustrations of the power of mind over the bare assemblage of discoveries. To be surprized with a new fact of practical utility in any department, arising from either accident

or from headlong adventure, is, at all times, very humiliating to the mind, which has been ineffectually pursuing a recondite study for the same object. So to the medical student, who has deeply investigated every main and collateral science of his profession, for the purpose of arriving at some fresh fact of practical application, the empirical discovery of a new remedy, in the hands, perhaps, of the ignorant and presumptive, appears as a reproach to his studies, and startles him for a moment into a contempt for his boasted acquirements. To the cool and circumspective mind, however, these "stubborn things" of fact and utility, appear as the thinly scattered landmarks on the misty and distant shore, the exploration of whose extensive boundaries and neighbouring seas, must nevertheless be attempted by the guide of the compass, and the constant principles of nautical science. Facts from whatever source derived, be they contemptible or noble in their origin, become to the physician of an inductive mind, the several ingredients of the crucible, from which, by the power of his genius, is sublimed that efficient principle, the acquaintance with which, is the surest introduction to facts yet unborn, and to remedies yet unfelt. The great errors to avoid, are, the abandonment of the mind to speculative knowledge, however dignified and captivating, and, what is even worse, without the plea of any mental exercise to excuse an error when committed, the superstitious repose on the empirical efficacy of remedies, associated only in memory, with

some happy precedent application, without any strict allusion to the corresponding or discrepant essentials of the respective diseases.

However useful systems of nosology have been to the student, and however much they throw over his profession the air of an exact and systematic science, by tutoring his mind into logical arrangement, and a dialectic set of imposing definitions ; it is, perhaps, a question not altogether free from doubt, whether they have not tended to perpetuate, in some degree, an Aristotelian attention to signs and ideas, instead of, to things and modes of action. The specious character of these systems are shorn a good deal of their celebrity and apparent usefulness, when the touchstone of a strict analysis is applied to them. It is then found, that they have been generally reared on the superficial foundation of the more obvious symptoms of disease—the exhibited consequences of disordered action, which are too often deceitful and ever varying, according to age, condition, and climate ; and as they have been studied, of too fugacious and uncertain a nature, to be the basis of a satisfactory and philosophical induction.

The beautiful arrangement of the Linnæan system of Botany, while it delighted and instructed the student of nature, lent a false fascination to the student of disease, who fancied, that the classification of morbid symptoms would afford a nosological system somewhat analogous in its aids to science, as the classified appear-

ances of healthy order and beauty in the parts of fructification, afforded to the study of vegetable life. This project, however specious and accordant with the prominent features of disease, soon found itself perplexed in descending to the generic characteristics of morbid action; and the stubborn display of similar symptoms, arising at times from diseases essentially different, and of the same appellative disease, exhibiting in its progress symptoms widely discrepant from each other, at length shook the confidence of the nosologist in such an artificial and forced arrangement, however much he joined in its general toleration, as an exercise for young minds, and as an elegant remnant of the scholastic routine of medical initiation.

If such an analogous attempt had continued to preside over the science of chemistry, it requires no illustration to shew, how deplorable and imperfect its present condition would have been. If the appearances and sensible qualities of bodies had still been the foundation of the science, we could have been only puzzling and exercising ourselves with an elaborate exposition of the four elements, instead of reposing our minds on facts and principles, as certain as the isles in the seas, and the science by which they are visited from every quarter of the globe.

Though chemists have long since discarded such a mode of conducting their investigations, yet many mineralogists, and some of the most eminent, retain a marked predeliction for forming their systems on the

external and physical character of bodies. This is a much more satisfactory and legitimate method, for raising a system, than the one that has been generally followed in nosology; as these characters scarcely ever assume the protean changes, which symptoms relative to many diseases often do. The study of mineralogy, confined to this method, would, however, be obviously imperfect, and most limited in its practical utility. So much so, is it reckoned by many possessed of the mere love of science, that systems formed on the essential nature of bodies, have appeared to them much more rational and satisfactory. Like the mineralogist, who forms his system on the external and physical qualities of the objects of his study, and who finds it a fair introduction to the mineral world, but who must resign his investigation to the chemical mineralogist, when purposes of utility and ultimate research are at stake; so the mere nosologist with his orders and genera, is equipped for the cursory superintendance of disease, and may confound the less learned with airy definitions, but when the issues of life and death are in his hand, with delicate textures and organs implicated in disorder, he is then beholden to the acute pathologist, who better can give the complaint "a local habitation and a name."

An overweening desire of simplicity has also retarded the rational march of medical science. Nature acting, it is supposed, by few and simple means, has induced many to believe, that these means—the

prima mobilia of all things, must first be searched out and ascertained; which being obtained, we have a key to all the arcana of health and disease. Here again, the progress of chemistry has taught many useful lessons; for instead of advancing to more simplicity, and displaying a few very intelligible and succinct principles, as it did when it emanated from Black and Lavoisier; it now consists of a vast multitude of facts, inclosing the orbits of principles more difficult to comprehend, and not so easily limited or defined.

It was this impatience of academical technicalities and rage for simplicity, that roused the innovating genius of Brown, who, with his graduated scale of health and disease, professed to have got hold of the lever by which nature operates on our corporeal condition. Notwithstanding the boldness and imprudence of his doctrines, their spirit had no little beneficial influence in the progress of Medicine. All men, of the least logic in their minds, could confute the latitude of the doctrines by their own innate contradictions and inconclusiveness; but few persons are prepared to deny the philosophical impulse they gave to medical study, and the benefit our continental brethren in the profession have derived and are receiving from his modified system, when compared with the antiquated codes, which they long had followed.

Perhaps, it was the unfortunate and reviled fate of Brown's theory, that has deterred many, of a stu-

dious and speculative mind, from advancing, since his time, any thing like the semblance even of a rational principle; being afraid, lest a fair theoretical deduction from fact and experiment, may acquire the odious name of a hypothesis, and themselves be designated the dangerous students of fancy and speculation. Abhorring the wide sea of theory, many have betaken themselves to the rigid province of experience, trusting that they can never be captivated or seduced beyond the reach of their senses, or inveigled in the ingenious cobwebs of proximate or remote causation. In shunning the Scylla of theory, however, we are apt to fall upon the Charybdis of empiricism, where facts and observations, though multiplied and interesting, yet stand so disjointed and insulated in the midst of proximity; that, if not surveyed by the faculty of generalization, appear like, as the objects of the natural eye would do, if vision were deprived of the power of perspective arrangement. The observing and the mental registering of a fact is one thing, the applying it to a useful or ingenious purpose is another. The one is the passive reception of a thing extrinsic to us, the other includes an active process of the understanding; and to this more noble faculty, we are indebted for almost every thing in the scientific Arts, and for many signal improvements in Medicine. The application of even cold and heat to the body, in states of disorder and in health, is remedially regulated by a knowledge of the theory of its action on the blood and living fibre; and

the anomalous fact of cold increasing the inflammation of a part, while, almost generally, it is the most powerful antiphlogistic we possess, can only be explained by the theorem, that the body is more susceptible of the stimulus of heat, in proportion to its previous reduced temperature; and of which theorem the ingenious Brown was, I believe, the author. The imperfect knowledge, we yet possess of the action of mercury on the body, has even led to many remedial applications of it, unassisted by any previous fact on the subject. Being once reckoned only a sialogogue and filterer of the impurities of the blood, its curative action was thought incomplete and even nugatory, except salivation was induced; but since its action has been discovered to affect the corpuscular fabric of the body, with an altered and vital commotion, it has been successfully administered, on *a priori* argument, in many diseases of quite different symptoms, and in diseased states of organs, different in their office and construction.

The acquaintance of the action of medicine on one part of the frame has, by the aid of physiology, made it beneficially applicable to several other parts and textures, when no fact previously was known, to decide the question about to be generalized. In this manner, medicines, that have been found remedial in one part of the mucous and muscular texture, by fair deduction, have also been applied and found useful in disorders of other parts of these textures, widely

remote from each other: and the late attention to comparative experiments and human pathology, is likely to make the profession still much more acquainted with the intimate nature of diseased action, and the rationale of medicinal agents, than all the systems of Greek derivatives could do. Notwithstanding the numerous records of facts and cases, to guide the industrious cultivator of medicine, yet it may be questioned, whether they have half so much influence in directing the practitioner's path through his profession, as a few general principles, whether true or false, have upon his practice. They are seen, read, and perhaps remembered, but the most genuine stickler for facts will at the sick-bed revert very often to some principle of obscure origin in his mind, though he would shudder to think he was giving practical effect to a theory. Personal acquaintance with facts, is a foundation, without which, no substantial structure of medical acquirement can be erected, however extensive the erudition and native talent of the individual may be. To the practitioner himself these facts are principally useful, as they are made subservient to impart confidence to his mind, and tact to his hand, without which no man can ever comfortably follow the profession. To others, however, the value of these facts is, in a great measure, lost, let them be detailed ever so perspicuously. To account for this, we must first consider, that a man may be very vividly impressed by a fact or experiment, in one or more points of its

sensible character, and may seize upon some one of its evanescent or less obvious phenomena, with sufficient force to render obscure the general observation; yet he may be unable to transcribe the exact impression the fact made upon his senses, and especially to pourtray the delicate tints, from which he has perhaps drawn every practical corollary, and all this with the most ingenuous and *bona fide* attempt to do so. Allowing the fact or experiment to be detailed, with a most scrupulous exactness, and without a single bias to any preconceived principle or theory, yet, thus standing like the original itself, it will not leave the same impression on all readers, through the various refracting *media* of their minds; it may even serve to build up or support theories of little or no relative similitude, while the fervor of some casuists may squeeze it into a corner stone of a most extravagant hypothesis—so true it is, that false facts, or rather, facts falsely viewed, are as dangerous as false theories.

Among the countless strings of cases, which fill the archives of Medical Literature, all of which may be, with the best faith, the transcripts of real disease, how few are remembered, as objects of curiosity and science, even of those that have been read, and how fewer still are those, which are kept in view, as the beacons and buoys of the intricate channels of practice. When not accompanied with the *autopsia* of disease, when fatal, they essentially fail in philosophical instruction, for a recital of symptoms alone

in many diseases is liable to a species of self-illusion, which in strict science should be carefully avoided. To illustrate this, it may be remarked, how difficult, in some cases, it is for two medical tactitioners to give the same report of an individual's pulse in certain habitudes of disease. What appears small and thready to one, will be termed hard and wirey by another, and even the terms quick and frequent are every day confounded, though they may exist separately or in contemporaneous action. The heat of the body, the aspect of the tongue and countenance, and the appearance of the fæces, are all liable in their minor shades of derangement to be differently reported, and subject to this illusive depiction of the pen.

Few practitioners, after the first inspection of disease, but, at least, form some notion, however unconfirmed, of the nature of the disorder; this notion immediately becomes the chief symbol or abstract in the mind; and to support it and give it confirmation, those symptoms are generally watched, which are well known to characterize such an abstraction, and are carefully remarked or noted; and even the doubtful are easily included in the groupe, which is to constitute the now fairly proclaimed disease. If an error lie here, it is most difficult to avoid it, for the physician who would witness the progress of even an obscure disease, keep his mind thoroughly neutralized from any allusion to its nosological or pathological character, and confine his attention to the

bare evolution of symptoms, as they successively arise, would be guilty of a callous empiricism, and be but an humble votary of the *medicine expectante*.

It were to be wished, that the science of medicine were as much allied to the exact sciences and to chemistry, in the certainty of its studies, as it is unfortunately allied to that of morals. The characters of individual disease are subject, in some measure, to that incertitude and *prejuge* in their depiction, which it has ever been the lot of personal character to experience. Prejudice and opinion have often guided the pen in the one, while theory has often biassed it in the other department; yet all men are agreed upon the abstract nature of vice and virtue, health and disease. The biographer, in pourtraying his characters, shows how good and great *traits* might be improved, and lays his ethical line and plummet to correct what is depraved, or repress what is exuberant: yet all the while "the secret why he did it," lies beyond his scrutiny, and the nearest approach to the real analysis of the character under review, is only to be gained when death commits the object of biography to the judgment of posterity. So likewise the physician may with far more unbiassed impartiality detail the features of disease to the world, and prescribe the powerful antiphlogistic or restorative; yet in dissolution alone can be more effectually revealed the secret seats of disease,---the genuine inference from symptoms---and the propriety of the treatment that was employed.

It is as difficult sometimes to resist the improper influence of preconceived theory and academical prepossession, however much we may be on our guard, as to withstand the palpable evidence of facts. At the moment we suppose ourselves in the attitude of a voluntary neutrality, the very use of the language, which we employ, imperceptibly places us more or less under the illusion, which we would wish to avoid; if it do not affect the free and unbiassed exercise of our senses.

" Les deux principes de verite, la raison et les sens, " outre qu' ils manquent souvent de sincerite, s'abusent " reciproquement l'un l'autre. Les sens abusent la raison " par de fausses apparences ; et cette meme piperie " qu'ils lui apportent, ils la recoivent d'elle a leur " tour ; elle s'en revanche."—Pensees de Pascal.

The ambiguity of language is also another source of the imperfections of the history of diseases, as it has added to the indistinctness of metaphysical science. Terms of healthy and morbid action are used in senses differing with the ideas of the respective authors; and the dread of countenancing promulgated theory has driven succeessive writers to adopt often a new tone and phraseology, about to become, in their turns, the objects of discouragement and avoidance. *Acid* and *alkaline* diatheses; *lentor* and *viscidity; spasm; sthenia* and *asthenia; nervous* and *debility;* have all, in their rotation, with many others, been the accepted and the shunned abstract of many medical

pens. Even the word *inflammation*, the most obvious of all in common use, as a term of disease, has been misunderstood, it is believed, as often as it has been misapplied. While many have confined the term to a particular class of diseases, others have extended its empire over almost every disease of the human body, and have ascribed every preternatural movement of blood to its open or concealed presence, in which opinion they conceived themselves to stand uncontroverted, by the fact of venesection being beneficial. How far this deduction may be often illogical, I shall endeavour to show in some succeeding essay.

That a systematic arrangement of diseases lends a very considerable aid to the knowledge of them and their proper treatment, must be acknowledged by all the least conversant with medicine. The desideratum, however, has been, upon what principles the system is to be formed; for it is next to an impossibility to construct even a synopsis, without enlisting some theory in the performance. The equivocal foundation raised on the symptoms of disease has been already alluded to, as unphilosophical, however facile and pertinent it may seem to the mere *routinier*. Physiology has been by others looked to, for a basis to nosology, and on the difference of the fluids and textures to erect an arrangement of the diseases affecting them. This plan has more the appearance of truth and philosophy, as it is found that similar fluids and tissues, in different and distant parts of the frame,

have a remarkable analogy and similitude in their diseases, and often yield to the same therapeutic means. This, however, is not invariably the case, nor does the contrary become merely the exception to the general principle, so as to make physiological data the ground-work of what is to be desired of a rational system. Besides, this plan has the radical difficulty in fully reconciling our notions of a *sequitur*, as it holds out healthy elements and movements as the substrata of morbid structures and phenomena, when the original texture and function can no longer be discovered, nay, even when they have ceased to exist. Different diseases of much severity may also, and do attack similar textures and membranes, from simple erythema to ulceration and gangrene; any one of which affections, though much modified from the generic texture in which it resides, yet may seize different textures at the same time, be attended by a constitutional disturbance of much difference in its nature, and may require a different treatment from what it would do at another time, in a similar affection of the same parts.*

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* In Dr. Good's Classification, examples may be seen of these difficulties in his elaborate and ingenious work; his genus *Bex* though placed under Pneumonica, is far more often a symptom of some of his Hæmatica. Sanguine plethora and Emaciation are also placed under the same class and order. Was this necessary?

These two systems, then, presenting so many inherent difficulties to a strict classification, and which difficulties, it is presumed, the most refined and correct labor and ingenuity cannot, in any material degree, overcome; medical men have, chiefly of late, looked to pathology for a deliverance from them, and on the nature of diseased actions themselves, have primarily attempted to erect a nosological structure. There can be no doubt, that if ever a rational system of classified diseases can be formed, so as to satisfy the strict inductive mind, it is in this province of medicine, that the structure must be reared. The doctrine of morbid action, as it essentially affects the blood and solid fibre, in their corpuscular organization, and in their early deviation from health and integrity, undoubtedly presents the more obvious basis, on which the whole attendant and succeeding phenomena should be arranged. In once getting hold of the ulterior *mobilia* of disease, as the chemist, when he detects some minute divellent or attractive element in his experiments; the superstructure of symptoms, however protean, and the lesion of parts, however different, are viewed as sequences of either necessary catenation, or of easy explanation. This system, though full of so much promise, is, however, attended with difficulties peculiarly its own, and which serve to naturalize, to some extent, the satisfactory advantages which it otherwise essentially possesses. For when it would be most desirable, and of most utility, to know the intimate and present nature and seat

of disease ; at that time the secrets of nature cannot be revealed, nor can they, in the majority of cases, be made part of our certain knowledge ; so that we are reduced to act remedially, from analogy of observable phenomena, and that in a retrograde mode of ratiocination. It may also be objected, that, though we had ready access to the most intimate part or organ laboring under disease, the real nature of the morbid action might escape or evade our senses ; and even if it were an object of some cognizable appreciation, yet the deep efficient cause might be so subtle, however powerful, as not to be an object of our senses or experiments. To this last objection it may be only said, that in common with all other human sciences, we have here to lament the imperfection of our faculties, and to confess, that a *ne plus ultra* is somewhere to be met with, in the pursuits of the most advanced in human intellect. It is, however, the legitimate labor of every follower of science, to make the ground reclaimed, as clear as possible, and perfectly to cultivate it to the very verge of this impassable boundary, wherever situated in his own mental capability ; without either despairingly conceiving it to lie in the outset of his pursuits, or, rashly attempting to overstep its barrier, to riot in the regions of hypothesis and speculation.

An impatience of confinement to the appropriate field of study and research, and a restless anxiety, peculiar to warm and imaginative minds, of advancing beyond the boundary of true philosophy, have been

the fertile sources of some of the ingenious hypotheses, dignified by the names of "Principles" and "Elements," by which the operations of health and disease have been professed to be explained. To this premature generalization, or the ambitious yet laudable desire of claiming acquaintance with the counsels of nature, we are indebted for the "Archeus" of Helmont; the "Conservative principle"* of Stahl, which was supposed to be continually endeavouring to counteract the inherent tendency to corruption and disease in the human body; the "Excitability" of Brown; and perhaps the modern Italian doctrine of "Stimulant" and "Contra-stimulant" diseases---not to mention the several supposed principles of a more confined and localized operation, which others have assigned to particular offices and structures.

Surrounded, then, as pathology is, with obstructions to a straight-forward study, and with temptations to hasty speculation, yet its history, of late years, more and more encourages the student to believe that many of these difficulties will be surmounted; and in proportion as they disappear before the weapon of research, experiment, and more extended observations, there will be the less inducement to quit the

* This term has been applied by the learned and venerable author of "Medical Logic," in a more restricted sense---forming only one of his ten *Elementary Principles* of life.

stability of the ground already made clear, for the hypothetical investigation of what is yet unreclaimed.

The knowledge of the grosser changes of the fluids and solid fibres in disease, naturally leads us to explore the less palpable phenomena of morbid action; and until we meet with an essential impediment to our progress, we have no right to stop short, and say that all beyond is conjecture and fancy. Chemistry has exhibited a splendid example of successful perseverance in its discoveries; and if medicine could arrive at such a goal, comparatively in her department, as the potassium of Davy, we might then for a while repose on our labors, and write our "*sic donec.*" The experiments, which originated with Haller, and which have, at different periods since, been renewed, varied, and conducted by different physiologists down to Bichat, Dr. Philip, and others, have opened a field, which ought to encourage us to hope, that medicine shall in time arrive at something so far certain, as to lay claim, with her sister seiences, to some philosophical accuracy.

From the data of physiological and pathological research and observation alone, can be deduced any accurate principles of health and disease, which can at all claim the legitimate title of a theory. For, as it is universally long sinee granted, that strict physiology can only be acquired from an intimate aequaintance with anatomy, and the motions of the living fibre; so

with every parity of reason, it must be acknowledged, that the doctrine of disease ought to be best learned, from as intimate an investigation of the nature of the morbid changes, as they affect both the fluids and solid fibres, as we may possibly attain to. It is the opinion of some, that the art of medicine may be as successfully cultivated by an attentive observation of the *lædentia* and *juvantia*, and that it by no means is essential to its practical study, to be over curious concerning the proximate changes, which constitute and elicit disease. It cannot be concealed, that some of the most eminent in the profession, have acquired a just honor to themselves, and contributed highly to the benefit of their patients and the public, who were neither deep physiologists, nor troubled their minds much about the intimate workings of disease; yet it must also be remembered, that the usefulness of these practitioners depended chiefly on strong natural talents for observation, and on a *tactus eruditus*, which cannot be imparted to another, nor made the subject of an embodied science, of which their contemporaries or posterity can receive the benefit. As far as a communicative science bears upon the studies and practice of the profession in general, it may safely be affirmed, that a correct theorem of a disease in any of its stages, and of the corresponding lesions of the structures implicated, will lead the practitioner to a clearer and more successful indication of what he should do, than if he had consulted the published practice of the

most rational empirie, on many supposed similar cases of disease.

The maxim, that "the knowledge of a disease is half its eure," generally holds good; for, to the circumspective physician, who is acquainted with the action of remedies on the living fibre, a knowledge of the nature of the morbid aberration before him, immediately suggests the appropriate remedy, as far as the state of the Materia Medica extant can supply.

The difficulty with the refleeting mind, is, to determine on the nature of the morbid action going on, and whieh may require much mental consideration; but when once it is deeided upon, the indication of the remedy to be used, follows as a ready eorollary—its beneficial applieation, however, depending on eircumstanees, varying with the violenee, duration, and inveteracy of the disease.

The want of attending more to the possibly discoverable state of the eapillary aetion obtaining in diseases, and to the different natures of whieh it is suseeptible, as well as to the several eauses, on which it at all times depends, has conduced very much to make readers and hearers confound diseases, of opposite essenee, under the same name, and of course to make them distrust the suecess of cases treated by others, in a similar manner. The words dropsy, inflammation, and dyspepsia, with several others, have been each often employed to express morbid processes, differing considerably in their essential eharacters, and consequently supposed to re-

quire different remedial indications. The intumescence of the first of these depending, very often, not on a weakness or atony of the vessels, as was long supposed, but on a contrary state altogether: indeed, without further illustration, the whole of the above diseases, in very many instances, may be, with greater justice, defined by one term, expressive of the capillary lesion, which is common to them all, than by terms, which convey a complete disassociation of their nature and more intimate characters. When diseases and their phenomena are studied closely, without any reference to their common nosological character, a short experience will show, that there is a common principle of morbid movement running through long series of them, which nosological systems as yet have tended to disunite, in spite of the most general definitions. For instance, the essential nature of the disease, termed dyspepsia, in most cases, may be shewn to depend on a state of the cæliac sanguiferous system, differing only in degree from the more serious and acute disorder of gastritis. In the one, there is generally a congestive state of the same fluid, which, in the other, runs into capillary distension, which is aided by an increased *vis a tergo*. In both, where no organic disease exists, the essential indication is to unload, or detumesce the engorged vessels, and to preserve them in an elastic contractile state, on which the functions of the healthy stomach depends. Without attention to this intimate view of the respective complaints, stimulants will be

often proportionably injurious in the more mild, as they are in the more violent affection of this organ.

A common principle thus having been observed by some authors of acuteness and reflection, it was natural to suppose, that diseases would be attempted to be considered under a more intimate and philosophical classification, than the system of the most ingenious nosology had yet done, with all the aid of the learned axioms of Linnæus. Without enumerating Brown, Darwin, Beddoes, and some chemical pathologists, as the accurate laborers in this definite field of research; we must look to such as Drs. Parry and Philip among the moderns, as the truly industrious pioneers, whom we are to follow, in our attempts to arrive at any thing like a certain knowledge of the laws of health and disease. Many may draw different conclusions from the facts and experiments, which such men have detailed; but, as long as these facts and experiments remain substantially correct and valid, they must ever continue, as data of established importance to the science, to which they relate, whatever theorems, the various gifts of reasoning minds, aided by future experience, may deduce from them. Allowing the principle of gravity to have been only recognized by Newton, as an ultimate law in nature; it might still have continued to have been but simply acknowledged, or altogether overlooked, if a transcendent mind, like his, had not generalized its influence, and made it the pivot of the universe. So it is with a few well verified facts in

medicine, concerning the nature of the blood and the containing vessels, the motion of the heart, and the action of the nerves; and the relative acquaintance with the precise effects of mechanical and chemical stimuli, on the animal fluids and fibres. These to some may appear to have little therapeutical bearing, but to the rational and thinking physician, they will remain, as the foundations of his practical indications, and be, to him, the frame-work of a fair inductive theory, when many systems of nosology shall have passed into neglect or oblivion.

It is true, as has been alluded to, that a successful prosecution of the practice of medicine is most materially enhanced by a long and strict study of the symptoms of disease, which are, to the practitioner, as the local and varying currents of the ocean, the state of the atmosphere, and the winds, to the navigator; but, as far as the art ever becomes a communicable system, or receives the dignified name of a science, so far general principles must be studied, and be held as the only way, by which all knowledge and experience in it can be made fundamentally available for the benefit of others; as astronomical and mathematical principles alone are the exclusive guides to the science of navigation. Symptomatology, however extensively studied, (and without an extensive study of it, no physician ever became eminently and truly useful) yet, as it only embraces the signs of disease, and not the morbid actions themselves, it may, therefore, be considered as

the handmaid only, however trustworthy, to a stricter and more definite study of the science of healing. It is difficult, it is presumed, to erect any principles on the symptoms alone, without adverting to the nature of the disease signified; and, therefore, it follows, that upon this ulterior and surer ground must be formed, with philosophical propriety, any thing having the semblanee of a principle or a system. These principles may be more or less true to nature, owing to the different degress of man's inductive powers; but if they are of the latter description, it is not owing to mistaking the field, whence they should legitimately be derived.

The laws of organic motion in the human body, not being exclusively subject to any of the prineiples of mechanical or chemieal agency, may lead some to despair of any precise axioms being established in the scienee of medieine, and others to deny, that if they were fairly established, they would have any decided beneficial result on the practice of the art. But, without presuming that the first effieient material cause in every disease may possibly be ascertained, it surely must serve very much to enlighten our ideas of the morbid sequences, which are generally the objects of therapeutical attention, to have the clearest demonstrations we possibly can, of the primary links in the morbid catenation. From an analysis conducted onwards in this manner, to as near the fountain-head of disease as possible, symptoms acquire their relative value,

and the grosser and contingent phenomena, as we proceed, are thrown out of the equation, until we arrive at the force and value of our ultimate research. Having through several processes arrived at the same power and quantity ; it becomes a rational deduction, that this power, so far ascertained, though perhaps short of its ultimate analysis, is the efficient member of the whole assemblage of the phenomena, which, as it were, radiate from it, and are subject to the influences of relative quantities and powers, to which due consideration is always to be paid in the process of our induction and reasonings.

By proceeding in this manner, though on ground not so palpable as that of the exact sciences, medical analysts have arrived at some principles, which are acknowledged by all to be next to demonstration, without incurring a belief in any of the occult causes, to which many of our ancestors were so fond of at once proceeding. A patient and analytical research of this kind, through the extensive region of human maladies, from the simple nature of a wound to the hitherto inexplicable hydrophobia, will, no doubt, lead as much to the rejection of a great deal of the mighty fabric of scholastic nosology, as it will to dispel the dogma of the unity of disease. Facts and experiments are daily accumulating in all departments of the profession, and as the repertory continues to be enlarged, men will be enabled more safely and efficiently to theorize ; and the variety and multitude

of the data will both be an advantage to the inductive reasoner, as they will assuredly prove the touchstones of the rash speculator. An hypothesis also, which is built on a small congeries of facts, will run every risk of being resolved into its original atoms, if another set of equal authenticity should appear with a contradictory import, and remain either unconfuted or unexplained. But not to take so severe a view of the fate of every theory, that may be elicited from a sound survey of any groupe of the great store of facts, and even allowing, that a more enlarged observation may correct much that has been advanced, yet the science is benefitted, rather than injured, by such intellectual exercises; for, we must generally admit, that the most of modern theories are honestly constructed, and fairly, and with few exceptions, beneficially applied to the treatment of diseases. So by the successive improvements of new labourers in the vineyard of the profession, assisted by the ever-gathering stream of facts and observations, the science of medicine may at length arrive, as the venerable Hippocrates of our country desired, "ad illum perventum, quem ultima "humani ingenii potentia consummaverit."

ESSAY II.

ON CAPILLARY CIRCULATION.

Notwithstanding the splendid discovery of Harvey, as to the course of the circulation of the blood, physiologists have still continued to speculate on the more precise nature and force of the motive powers concerned in it, and to investigate, whether the power employed is derived solely from the single mechanism of one organ, or whether it is the aggregate of several powers of the animal machinery---all acting synchronously, and with forces more or less independent of each other. The first discoverer, being naturally inclined not to permit the beauty and unity of the moving power of the blood to be impaired by any collateral or consentient aid, attributed all the movements, which he saw in operation to the agency

of the heart alone. This opinion has ever since been most generally adopted, and of late it is supposed to have received additional confirmation, from a more perfect hydraulic view of the action of the central organ. Harvey, with those who confined themselves to his first discovery, placed the circulatory office of the heart, chiefly in the left ventricle, so far as the aortic circulation was concerned; and, from its propulsive powers alone, alleged this circulation to be kept up. Some late physiologists, amongst whom is Dr. Carson, have not hesitated, however, to attribute as much motive power to the dilative action of the right auricle and ventricle, and to make them an instrument of powerful suction, sufficient to influence the natural circulation, even to the terminations of the capillary veins, where the propulsive force of the heart is supposed to be finally expended. Other enquirers, not satisfied with the theory of the unity of power in the heart, for carrying on the circulation, have assigned a considerable degree of auxiliary power to the blood-vessels themselves, and among them, Haller and Hunter are the most eminent. Without more than alluding to these several opinions about the great powers at work in the general circulation, and which have been, at stated periods, so ably and amply discussed, since the era of the original discovery; I shall only say that I have not been so fortunate as to ascertain, with any satisfaction to my-

self, the extent of the suction-power of the heart, as it has abstractedly appeared to others.*

The nature and moving forces of the circulation in the smaller order of vessels, both of arteries and veins, being the more immediate objeet of this essay, I shall content myself with merely adverting, oecasionally as the argument or the illustration may require, to the more conspicuous powers of the general circulation.

The subject of capillary circulation has perhaps been rather neglected in the more palpable and imposing interest of the action of the heart and large vessels; and its nature and phenomena have been considered as the subordinate effects of the greater machinery,

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* To attempt a proof of this active dilatation of the heart, I procured, in succession, the hearts of two sheep to be extracted immediately on opening the large vessels of the neck. They were plunged instantly into tepid water, and each afterwards gave three or four good contractions, sufficient to empty themselves nearly of the water which successively had filled them; but their intermediate dilatation was effected by no quick or distensive motion, nor with an impulse against the hand; it rather seemed an interval of relaxation, until the cavities were again filled. Besides, there is a physiological difficulty, which is not easily explained on the theory of the active dilatation of the heart. Is it a muscular or an elastic ligamentous action? If of the former nature, we have no anatomical evidence, it is presumed, of any such muscles so acting. If, again, it be owing to elasticity; where are the resilient fibres to be seen, and why do we find the dead heart, in every butcher's stall, hard and contracted? Not so do we find the dead elastic arterial tubes.

in the theories of which, whether mechanical or vital, the capillary properties and phenomena were thought to have a necessary and consecutive explanation. The idea, that the minute vessels were only a descending series of the same anatomical calibres and tissues with the larger tubes, lent much countenance to this comparative neglect; and even when the capillaries were made the object of more attention, they were still, too generally, thought to be subject to no other laws, but to those, which governed the more expanded diameters of the same continuous tubes. But this system of vessels rises into distinctive importance, when it is considered, that, in the long catalogue of diseases which affect the frame, by far the greater number have their *fons et origo* in the capillary tissue of vessels; and even when the larger trunks of the circulation are the original seat of violence or morbid lesion, much time cannot elapse, before the minute vessels of the part or system are involved in the local injury or disturbance; whilst to the nervous or contiguous sympathy of this latter set of vessels, the offices of medical attention are chiefly applicable. When the more conspicuous parts of the circulation are also secondarily affected with disease, to the production of symptoms exclusively pathognomonic of their individual affections, it is still to the capillary system that we must direct many of our remedial means, and through its *media*, we must expect to arrive at the chief indications, which we may have in view. The

importance of this system is pressed upon all physiologists, from its first evolution in *ovo*, to the full grown frame of the animal: for what was coefficient with the original breath of life, before a heart or lungs were in action, or even, perhaps, formed, continues to preserve its power and influence until every phenomenon of life is extinguished. So also to the pathologist and practical physician, the capillary system of vessels is of paramount interest. In them the former sees or places the radical movements of most diseases, and in the severe or the great exhibitions of morbid action or growth, beholds the elaborate toil or the deranged operations of these vessels; whilst the latter, in endeavouring to subdue or alleviate the miseries which their preternatural actions have produced, to their delicate tubes, looks for a change of the morbid process, and to them generally and principally directs his means of counteraction and cure.

As remedies, for the most part, do not act in masses, or on aggregated portions of the animal body, but on the corpuscular texture of the part or system affected, so there will long remain every motive for investigating the nature and properties of this intimate laboratory of vessels, when the nature and powers of the great circulating vessels may be, to all, most satisfactorily ascertained. That the laws, which govern these two systems of vessels in the conveyance of the blood, are very different, is abundantly evident, from the experiments, which have been instituted on the subject; in-

dependent of the philosophical presumption of the different properties, which large and capillary tubes have for the transmission of fluids. At any rate, if the respective laws are not essentially different, as powers at all allied to any prineiple in natural philosophy, the phenomena, which they represent, are yet so separate and distinguished, that the same law must reeeive a most obvious modification, before the two distinct effects can be elieited. The principles of mechanics and hydraulies afford so much aid, in explaining the circulation of the blood in the heart and large vessels, down to a very small series, that a mind of moderate mathematical preeeption finds little difficulty, in very satisfactorily aeeounting for this piece of animal mechanism. But when the sanguineous current is traced through canals having a diameter, from $\frac{1}{200}$ to $\frac{1}{2000}$ part of an inch, the last of which will freely contain a red globule of blood, our mechanical prineiples fail us ; and we are thrown on the research of some new or additional powers, by which we may be enabled to trace the stream of life, baek to the fountain-head, whence our rationale started.

The principle of a foreing and sucking pump, is as obvious, as any piece of practieal mechanics, and would be quite suffieient to aeeount for the whole eircle of the current of the blood, however numerous and extended the vessels might be; provided that their diameters were of suffieient extent, that the sum of the resistanee of their internal surfaces and flexures would

not exceed the sum of the forces of the propulsive and suction powers. But, as the pressure on the blood in the large arteries is placed by Dr. Hales, and agreed to by Dr. Young, to be nearly equal to the pressure of a column of seven feet; and as the whole resistance of the internal surface of the arteries from friction, to the motion of the blood, down to those of the diameter of $\frac{1}{1100}$ part of an inch, is stated by the above latter philosopher,* to be equivalent to a column of eighty inches; it is difficult to form an idea, on this hydraulic view of the subject, how the small excess of power, on the side of the heart, can propel the blood through the still descending series of vessels, onwards to those transmitting only one globule, and of the small diameter of $\frac{1}{2000}$ to the $\frac{1}{2500}$ part of an inch, where the resistance must be very greatly increased. Admitting that the resistance is diminished in some degree, with the increasing diameter of the cone of vessels, as they recede from the heart; yet, it must be remembered, that the friction is also extended and increased, on the hydraulic principle, that "the retardations from frictions are inversely as the diameters," so that there is some mathematical reason to presume, that the circulation would be arrested by the resisting forces, before the blood had reached vessels of the above mentioned minute diameters.

As to the exact size of the red globules of the blood,

* *Med. Liter.* 1823, p. 611.

the observations of several observers are very discrepant; for Mr. Bauer and Sir E. Home give to them, from mieroscopic admeasurement, a diameter of $\frac{1}{1700}$ part of an inch for the whole globule, and $\frac{1}{2000}$ part, when it is divested of the external, or colouring matter,* and Dr. Young says, he has every reason to think, that their greatest diameter does not exceed the $\frac{1}{3000}$, or even the $\frac{1}{3600}$ part of an inch.† I have assumed their greatest diameter to be $\frac{1}{2500}$ part of an inch; as it more analogically agrees with my observations on the globules in cold-blooded animals; for, by measuring the number of capillary vessels in a seetion of an inch, under the microscope, I could roughly caleulate the diameters of the vessels, and thence the size of the distinctly visible globules. It may have escaped, however, the observation of some observers, that the red globules do not always preserve the same diameter: observation has certainly indueed me to suppose, that they are capable, in some degree, of dilatation and eondensation.

Though Hales estimated the absolute force of the heart to be equal to fifty pounds, yet it must be evident, that this force is never exerted, as Mr. Hunter, from experiment, found, that a small seetion of the aorta broke with a weight of ten pounds and a half; and that one of the pulmonary arteries gave way with a weight of eleven pounds and three quarters. The force of the heart is again ealeulated, by Dr. Young, at a pulsation,

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* *Phil. Trans.* 1818. † *Med. Literat.* 1823, p. 613.

(which is different from its mean pressure on the blood,) to be rather more than the pressure of a column of one hundred and one inches high,* which is not more than about three pounds and a half on the square inch.

Dr. Young, in the experiments on glass tubes detailed in his Croonian Lecture, found, that as the diameter of the tube was diminished from one-fortieth to the one hundred and seventy-second part of an inch, the resistance to the forcible transmission of a solution of sugar, dissolved in five times its weight of water, was increased, from twice to five times as much as the resistance was increased to water alone. On these experimental data, which are, no doubt, correct enough, as the resistance is inversely as the diameters of the tubes, and the viscidity of the fluids; the resistance to the same solution in tubes, not exceeding the one-thousandth part of an inch, must, from the above ratio, be about eighteen times as much as appeared in the larger tube experimented on, and nearly double these times greater than the resistance of water. Then, as water, by Dr. Young's other experiments and calculations, is shown to meet with a resistance in the arteries, equal to a column of twenty inches, provided the whole arterial system were a series of inorganic tubes, gradually decreasing in diameter, but increasing in the area of the joint section of the branches; and as the above solution of sugar may be nearly of the density and viscidity of the blood, it is easily seen, what

* *Med. Lit.* p. 616.

an enormous degree of resistance must be formed, on the hydraulic theory, to oppose the pressure of the heart (joined to the mean velocity of the blood), in the capillaries of the diameter of $\frac{1}{1000}$ part of an inch, and all this short of the minutest section of these vessels.

Not to make, however, Dr. Young's experiments and data the foundation of any calculation, beyond what they ostensibly are confined to in his lecture, but seeing, that the laws, which regulate the transmission of fluids through capillary tubes, are different from those which relate to pipes and canals, I was induced to bring the subject to a very short and easy experiment. Having procured three capillary thermometrical tubes, of the respective diameters, as near as could be calculated,* of a fiftieth, a hundredth, and of a hundred and eightieth part of an inch, and each being about two inches in length; I fastened them successively into the pipe of a free working syringe, which contained about half a pint of water, and I loaded the piston, which was of the diameter of 1-6 of an inch, with weights perpendicularly placed, until the *stillicidium* was forced into a stream or jet. The results were; it required four pounds for the larger tube, and twelve for the second, to force the water into a con-

* The diameters of these tubes were calculated from the constant number of .018, which is the product of the diameter multiplied by the height of ascension, for spirit of wine in capillary tubes, as stated in the Encyclop. Brit. 4th Edit. and may be held as sufficiently correct for the above experiment, though the constant number is stated as a little different by other authorities.

tinued stream ; and sixteen pounds for the one of the smallest diameter, did not produce a capillary jet, but additional manual pressure accomplished it. The several pressures then on the square inch will be ; for the tube $\frac{1}{50}$ of an inch, about two pounds, for the one of $\frac{1}{100}$, six pounds, and for the smallest, eight pounds did not produce a continued stream. The mean pressure, of the heart being calculated to be about three pounds on the square inch, and six pounds, or twice as much being required to give a continued stream in a glass tube of $\frac{1}{100}$ of an inch in diameter ; it may fairly be enquired, where is this additional hydraulic force derived from in the capillary vessels---the superior viscidity of the blood to that of water, being four times as great, not being taken into the question.*

From the data laid down by Dr. Young, the velocity of the blood, in the capillary arteries of $\frac{1}{1100}$ part of an inch in diameter, is calculated to be eight hundred times less than it is in the aorta, where it is about eight inches and a half in a second, while in the capillary vessels of the above calibre, it is but the ninety-third part of an inch in the same portion of time.† This calculation, resulting correctly from the principles assumed, would, it is presumed, render a

* The data, which were taken for the pressure of the heart, are those used by Kiell, Dr. Young, and others, and which appear very correct for an adult ; namely $\frac{3}{4}$ of an inch for the diameter of the aorta at its base, and a seven feet column for the heart's mean hydrostatic pressure.

† *Med. Liter.* ut supra.

full venesection from the arm a far more tedious operation than it usually is. For, allowing, as physiologists do, that about an ounce and a half of blood is thrown out by the heart in a pulsation, or 1-87 ounces in a second, with a velocity of eight inches and a half in that time, and that the tenth part of the above quantity, or .187 of an ounce, is proportioned to each axillary artery in a second; the whole quantity which would flow in a minute, from one of these arteries when divided, would be only 11.22 ounces, provided the velocity was not increased. But, as the blood, in the capillary system of vessels having a diameter of $\frac{1}{1100}$ part of an inch, which are capacious enough to hold two globules, with free motion, in their transverse axis, has only a velocity eight hundred times less than that, which furnished the above supply; it is not very easy to conceive how any considerable quantity of blood could be extracted, in any adequate time, to meet the urgencies of some diseases, or to fulfil many speedy curative indications. Granting, that the velocity could be increased in the larger capillaries, and that large anastomoses might facilitate the readier transmission of the blood from the arteries to the veins; the difficulty yet remains in considerable force, from the velocity of the blood, in the smaller capillaries, through which a great part of it circulates, not being acted upon by any adequate cause for to increase that velocity in them. In venesection, moreover, the propelling pressure is not necessarily required

to be increased, and the supposed suction-power of the heart can have no influence on the interrupted veins. The capacity of the joint section of the capillaries at the above minute diameter, it is true, is about eight hundred times that of the area of the aorta ; but when two to three pounds of blood are taken away at once, the velocity in the capillaries would require to be vastly increased to transmit this quantity, in a few minutes ; as the greater part of the blood cannot be in the vessels of the arm, at the commencement of venesection, but must flow in the mean time, directly from the heart.

The power of the heart, therefore, though of great force in the immediate sphere of its action, and to a considerable distance, in the descending series of the leading linear vessels, as a hydraulic engine, must be reckoned as imperfectly adequate to propel the blood, by its own motive powers, through the entire circle of the body ; even allowing it to possess the active suction-power, which has been attributed to it, but which can hardly yet, in strict data, be granted---though no doubt, some small degree of this dilative power takes place, from the mere consent of habitual action, between the column of venous blood and the recipient cavities.

A good deal of independent and auxiliary power has been given to the propulsive properties of the arteries themselves, and it is alleged, that their contractions on the volume of the blood, alternating with the systole of the heart, very considerably tend to carry on the circulation. Granting that the arteries

possess this automatic contraction, which is a disputed point in physiology, it is submitted, that a little consideration will show, that such a power would act as readily in driving the blood to the heart, as into tubes of decreasing dimensions; and if it do act at all, as a propelling force, it must use the column of blood next the heart, as a fulcrum, and so detract from the free force of the heart itself. In this way, the pulsative contractions of the arteries would act more injuriously on the propelling power, than if the vessels were mere inelastic tubes, gradually losing in diameter, what they more than gained in the aggregate capacity of their ramifications.* As to the aid which the *capillary attraction* of the small vessels would give in promoting the circulation of the blood, this peculiar property would have the effect of retaining the blood in the vessels themselves, but not of transmitting it onwards to the heart.

The certain and probable powers of the central organ, with the aid of the alleged contractile properties of the larger arteries, and of the *capillary attraction* in the smaller ones, are then considered, on the fair

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* "And I apprehend, it will appear demonstrable, that they (the arteries) are much less concerned in the progressive motion of the blood, than is almost generally believed." "But in the case of an elastic tube, (speaking of the pulse) the velocity of the transmission of an impulse being rather diminished than increased by an increase of tension, the reasoning is still stronger and simple."—Dr. Young ut supra.

latitude of mechanical reasoning, as insufficient to carry on the entire circulation; nor will their conjunct powers, as above noticed, giving to the arteries properties, by no means demonstrable or probable, account for many phenomena, wherein the circulation of the blood is intimately connected. Seeing also, that the heart can have little or no direct effect on the capillary circulation, at least surely, of a local and elective nature; the blushing of the cheeks, and some evanescent erythemata, with the turgescent states of the nipple and penis, cannot be ascribed to its action, but chiefly or solely to some intermediate sanguiferous function: and presuming further, that mathematical principles have failed to account for, in all the subordinate parts of the circulation, what the Harveian discovery was long thought to have perfectly explained; it now remains to take some notice of, and to attempt to investigate the additional powers, by which the transit of the blood is completed through the entire circuit of the body.

The debateable land, as it may be termed, which lies between the termination of the leading and linear arteries and veins, and over which the heart is presumed to have no direct predominance, as has been endeavoured briefly to be shewn, is, as yet, an undefined part of the circulation, and upon which little definite information can be gathered from the records of physiology While some see little or no difficulty in accounting for the conveyance of the blood through this region of vessels, in the same manner, by which

it is propelled through the larger ones, on the principles of an easy mechanism; others again, being less adepts in mechanics, or else more doubtful of the general application of their principles to the functions of life, are satisfied with losing sight of the blood in the smaller arteries, and with taking it up again in the corresponding veins, without troubling their minds much how the *hiatus* in the circle of the blood, and in their own reasoning, is to be filled up.

Without adverting further to the imperfect state of the science in this department, I shall endeavour to describe, how far some of the chief observations and experiments, which we possess, have advanced us, in the investigation of the nature and physiological properties of this important class of vessels: and, however limited has been the progress of any research, undertaken in this or in any other province of intimate physiology, it is still better than the abstract application of arbitrary principles, however beautiful, to the obscure and unmechanical economy of the human body.

The anatomy of the blood-vessels in the dead body can only be pursued to a certain step in the descending series, and their textures thus far can be moderately well ascertained; but, when we attempt to trace them anatomically any farther, they become lost in the surrounding organs and tissues, and nothing like vascular continuity can be observed. It is only by injection in the dead, and by observations on the living animal, that more insight can be obtained into the

structure of the minute blood-vessels. The most delicately managed injections of these vessels, however, presenting only the frame-work of their ulterior ramifications, and affording to us little capability of verifying their precise structure, except to show us, what it is not; and above all, throwing no light almost on their circulatory functions, recourse has been generally had to observations and researches made on the attenuated membranes of living animals.

It appears, from all the strict experimental researches, that have been made into the structure of the capillary system, by Leuwenhoek, Haller, Hewson, Spallanzani, Bichat, and Dr. Thompson, that it is of a very different nature, from that of the larger vessels of the circulation, and that it has little in common with them, but as being the continuous conduits of the same fluid. The muscular or elastic fibrous tunic of the larger arteries, about which there has been so much controversy, is either lost in the capillary tissue, or is so entirely attenuated, that it is incapable of demonstration, even by the aid of a strong microscope; and the arterial capillary tube is found to consist merely of the inner thin, and pellucid membrane, which lines the internal surfaces of the whole arterial system, and the ventricles of the heart. The cellular coat of the larger vessels seems not, any longer, to form a distinct sheath to the diminished vessels, but is lost in, or becomes the cellular bed, through which the capillaries are dispersed. The vessels of the venous part

of this system appear to be of a more lax and distensible construction, and of more tenuity and transparency of texture, than those of the arterial portion appear to be: but where the ultimate arteries merge in the extreme capillary veins, no difference has been observed in the texture of the tube, and their distinctive systems are only known, from the progressive and returning currents of the blood.

The manner, in which the capillary vessels are distributed, is as different from that of the larger vessels, as their respective vascular structures. Instead of ramifying at irregular distances, from larger to smaller subdivisions, in a regular decreasing series of diameters, and in directions more or less linear; they form an expanded reticular work, the meshes of which are of various polygonal forms, and the extreme intersecting vessels are of diameters nearly equal to those of each other.* This net-work, however, is principally composed of veins, and often appears to be an intermediate system, between the arteries conveying the blood to the part and the veins carrying it back; or, in other words, it seems like an extensive irrigation, of which the larger capillary arteries are the leading conduits, and the corresponding veins the channels, by which the

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* Vide *Deux Memoires sur le Mouvement de Sang, &c.* p. 7. Alb. de Haller, A Lausanne, 1756, and Dr. Thomson's *Lectures on Inflammation*, p. 77.

vital fluid, deprived of its fertilizing properties, is withdrawn. The enquiry on this subject, however, proceeds only to a certain extent in the analysis of this texture, for though the circulation has been traced, both in cold and in warm-blooded animals, to vessels transmitting only a single globule of red blood, (which is reckoned by the average microscopic admeasurement of the above observers not to exceed the $\frac{1}{2500}$ part of an inch,) and even to such an ultimate stage of observation, that no further vessels seemed gradually to be lost in obscurity and indistinctness, from their indefinite minuteness; yet an exhalent or secretory orifice, or its vessel, has not been, as far as I understand, detected, with any optical or anatomical satisfaction. Instead of which, every the minutest vessels appear to be closed and continuous tubes. Conjecture may help out the analysis, in supposing, that a certain portion of the colourless vessels, in which a current has been observed, has patent terminations, or that a species of percolation takes place from the sides of all the vessels of the reticular expansion; but these very probable suppositions have nothing to do with any strict deductions or reasonings on the subject. That many varieties of fluids are separated from the contained blood is certain, but the exact physical manner in which they are so, cannot yet form the foundation of any philosophical induction.

It has been questioned, whether experiments and observations made upon the vessels of cold-blooded

animals, as frogs and some fish, can, in strict reasoning, be made available to physiological inferences, as to the nature and properties of the same vessels in those of warm blood, as in those of man. Besides that Dr. Munro and Fontana observed, that the vascular systems of both these classes of animals obey the same laws, though they differ in some other circumstances; Spallanzani succeeded in distinctly observing the circulation of the blood in the arteries and veins of an incubated egg,* and more recently, Dr. Philip, by the aid also of the microscope, witnessed the circulation in the mesentery of newly-killed rabbits, when it exhibited nearly the same phenomena, as in frogs and salamanders.† There is hence every reason to consider the data, furnished by experiments made on cold-blooded animals, as perfectly available for all reasonings and deductions in human physiology. Instead, then, of endeavouring to solve the theory of the circulation through the minutest vessels, on the principles of the most refined mechanism in natural philosophy, strict enquirers into the nature of the vital and moving powers of the blood, have attempted to bring these powers directly under observation, and make

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* *Experiments on the Circulation of the Blood, &c.* by the Abbè Spallanzani. Trans. by R. Hall, M. D. London, 1801.

† *An Experimental Inquiry into the Laws of the Vital Functions*, by A. P. Philip, M. D. &c. &c. 2d Ed. 1818. Exp. 62 and 63.

them the object of a detached analysis. And though there are some functions of the more perfect animals, as that of vision, which lend a strict and beautiful illustration to the science of light, and to the mathematical laws to which it is subject; yet there are others, which no refinement in mathematics can explain, and of these, with much deference it is submitted, the capillary circulation is one of the most interesting and important.

Notwithstanding the very elaborate and finished experimental inquiry, which Haller made into the circulation of the capillary system, upwards of sixty years ago, than which nothing more materially new has since been discovered; and besides that Dr. Thomson and some others have repeated many of the Baron's experiments, though with a few physiological inferences somewhat different; it was presumed, that a further recapitulation of some of the more general ones, would, at least, serve to place the data already afforded, in a more impressive light to myself, and give more confidence to any deductions, that might be formed from a general survey of the principal published experiments. Besides, a repetition of this sort, though limited, promised to afford some facility in reconciling the few different observations and inferences, which seemed to exist between some of the observers on the subject; and it was further hoped, that a collation, thus conducted, would more satisfactorily confirm the conclusions already made, or would lead to some collateral doctrines of tolerable certainty in either physi-

ology or pathology. With this view, the following experiments, with several others of similar importance, and of the same nature and general result, were instituted in the summer of 1822. They would have been prosecuted to a much greater extent, if an amaurotic affection of one eye of the experimenter had not made its appearance, during these and some other optieal pursuits; and the delicacy of the organ since has deterred him from renewing similar investigations. All of them were performed on the webs of frogs' feet, with the exeeption of a few on their mesenteries, and the webs of young ducks' feet were twiee subjeeted to experiment. Those detailed are selected indiscriminately, and principally from the experiment not happening to be interrupted by the uncertain vocations of the day. The frogs were enelosed in muslin bags, except the limb at the time required, after the mode used by Dr. Thomson, and care was taken to keep the animal in as natural a condition as possibly could be aeeomplished, when the objeet of the experiment required it.

Exp. 1.—The frog being at rest, and confined in the bag, the web of the foot was brought into the field of vision, and the circulation was distinctly observed. The blood flowed through the arteries, sometimes in an uninterrupted current, but more frequently by repeated propulsions; the intervening retardations, answering to the supposed diastole of the heart, being very obscure, but generally observable: they also appeared like pauses in the current, and by no means, as if

they were occasioned by contractions of the arteries, which never appeared to contract alternately with the pulses, but their diameters varied only by slow degrees, and with the different states of the part. The motion of the blood in the veins was much slower than in the arteries, and in the larger capillary veins, an indistinct oscillation was observed, answering in time to the action of the auricle. The terminations of the capillary arteries in veins were plainly seen; the globules traversing very quickly the extreme arteries, more so almost, than when they were in the branch from which they immediately proceeded; and their arrival in the corresponding veins was marked by the slower motion they assumed, which, however, was still quicker than the circulation in the vein by which they were received. A sudden pounce on the body, or pressure on the chest, diminished the velocity of the blood, which soon, however, resumed its wonted pace, when the animal was left alone. The capillaries, when rendered more visible by turgescence, seemed like a mesh-work of irregular squares; and the arteries held a more direct course through these meshes, which were chiefly composed of veins. On the application of Aq. Ammon. by the pencil, the circulation seemed for a while to be increased in velocity, and the arteries to be more diminished in diameter. Soon the lesser capillaries became more visible, and according as all the vessels became more enlarged, the velocity of the blood seemed diminished, and became very much retarded in the veins. A solution of Mur. Sodæ was quickly followed by increased redness and enlargement of the vessels, then by a retardation; and by a farther application, a complete stagnation followed, commencing in the smallest capillaries, and then retrograding to the arterial trunks, the blood in which was seen, to be as it were, forced upon itself, red globule on red globule,—the transparency of the vessel disappearing, and each faint propulsion only adding more and more to the

stagnant canal. After the circulation in one vessel was restored by wiping off the solution, and by gentle pressure, two or three coagula were seen to be carried along with the renewed flow of the blood in the artery. The frog was a weak one, from being kept some days in confinement.

Exp. 2.—On a fresh frog.—The natural circulation in the web showed considerable velocity, with an obscure saltation, but when the velocity was very quick, all appearance of pulsatory motion vanished. The red globules seemed to dart through the capillary meshes from the more direct arteries to the veins, and appeared to be as much attracted by the one set of vessels, as to be propelled by the other. The capillary plexus is a separate set of vessels from the more linear arteries and veins of the part, and is composed of vessels, nearly all of the same size, admitting in the area not more than two red globules; and when the circulation is very quick, only one follows, or rather darts after the other, in rapid succession. The red globules seem at some distance from one another.—A perfect retrograde movement of the blood was observed in several neighbouring arteries and veins; it continued so for two or three minutes, when a fresh motion of the frog put all into the natural movement. An *error loci* was observed, in some globules adhering and moving on as a coagulum into a small capillary. A sudden pressure on the limb, or stroke on the animal, arrested, for a few moments, the circulation. Ol. Terebinth, and Aq. Ammon. seemed to increase the velocity of the blood for a little, with diminished diameters of the vessels; but this was soon followed by their enlargement, and the globules became more distinct, and slower in motion. The application of the salt solution always retarded the motion of the blood, and enlarged the diameters of the vessels from the very first; and a continued application produced congestion, first

in the various capillaries, then in the larger veins, and lastly in the arteries leading to the part, which congestive state could be restored to contraction sometimes by Ol. Tereb., when the paralysis was not excessive. Capillary arteries in motion were often observed to traverse wide plexuses of venous capillaries in a state of congestion. A puncture with a needle was soon surrounded by congestion, first in the venous, and then in the arterial capillaries, until the circulation all around became very slow, and seemed stagnated—the arterial blood being returned from the part by the larger anastomoses. The stoppage of the current by the solution of salt, seemed to be owing to the globules themselves being the direct passive instruments, as they were arrested in canals large enough for their passage. Both arteries and veins, in one section of the foot, can be made to contract or expand by several applications, while similar vessels on the other side of the toe preserve their natural state. Stagnation in contracted vessels, except from the application of cold, was never observed. Two hours after the above experiments, when the parts had been inflamed by salt, &c. the blood was found not to have regained any circulation; on the contrary, the vessels were shrunk, and more free of blood.

Exp. 3.—A fresh frog.—The application of moderate stimuli excites the circulation a little, but enlargement of the capillaries soon takes place with a diminished velocity. The capillary veins are always the first to be enlarged or congested; and when all circulation ceases, or only a very slow one remains in all the capillary meshes, it is kept up through the leading arterial branches, propelling the blood into the contiguous veins, with a velocity more or less diminished. Two states of capillary inaction are observed; one is similar to a collapse, where no red globules, or no circulation could be

seen in the vessels, and the other is a congestive state, where the red globules are temporarily or permanently stagnated, and the diameters of the vessels enlarged, as happens after the application of the salt solution. An enlarged diameter of either arteries and veins, with an increased velocity of blood, is not observed; the natural circulation seems to be the quickest. It seems impossible to measure the velocity of the blood; it being sometimes so quick, that its motion cannot be observed, except by much attention, and then the track of any globule or set of them soon disappears—the microscope no doubt increases this appearance of rapidity.

Exp. 4.—On a frog.—The natural circulation of the arteries in the web almost invisible, and without any red colour; but as soon as it was discovered, it was observed to circulate with considerable velocity, and the globules were not easily to be traced. Extension and gentle fastening of the foot even by the fingers, increased the flow of blood, and soon filled many of the colourless vessels with red globules. The application of Aq. Ammon. and more particularly of the salt solution, soon rendered the whole capillaries visible, and of double their former diameters; the circulation becoming slower, and congestion following in the veins, and lastly in the arteries.—The brain was crushed, and the circulation observed in the foot previously unexperimented upon. The vessels sooner than before became more visible, the circulation also became retarded, and congestion took place in the order of vessels as before remarked; but the circulation continued twenty minutes after the injury of the brain, and lastly the blood slowly retired from the smaller vessels of all descriptions, and left the web pale and flaccid.

Exp. 5.—The web of a young duck's foot was made the subject of this experiment.—The veins in beautiful branches were easily

seen by a common magnifying glass, but the arteries were only visible after some stimulation. The web could not be rendered transparent enough to see the red globules by the microscope. Aq. Ammon. was applied to both sides of one of the divisions of the foot; in two to four minutes great contraction took place in the large vessels; so much so, that many branches were rendered invisible, and others appeared like the finest hairs, which, before in their natural state, seemed three times the diameter. It was not a mere recession of the blood, for the line of the larger vessels was very distinctly contracted and well defined. After the space of about four minutes, all the vessels acquired their former natural diameters, and still further enlarged to complete phlogosis of the part, or to what may be termed inflammation. A fresh application of Aq. Ammon. produced a fresh contraction, but it was not near so complete as the former. The other foot was treated with a saturated solution of Mur. Sodæ, which application was soon followed by great enlargement of the vessels, especially of the larger veins in the web, which seemed much congested, until bathed on both sides with Aq. Ammon. when after five minutes, general contraction was produced, and many of the small vessels were rendered invisible.—During the above experiment, the animal scarcely struggled.

Exp. 6.—On a stout frog, newly caught.—In the transparent web the circulation appeared very active; and when the speculum light, from the clear sunshine, was thrown upon the web, the whole appeared to be in a sparkling motion, and reflected all the prismatic colours, from the moving and apparently colourless globules in the capillary vessels. In a few minutes, the arteries were quite visible, with the blood darting through them, with immeasurable velocity, and the veins also became enlarged, with a velocity seemingly diminished to one-third of what it previously was. The animal not strug-

gling, nor confined harshly, nor wounded, Aq. Ammon. was applied to the course of the arteries with the pencil. It then struggled from the stimulus; the vessels were then examined, but little alteration seen. In two to four minutes a visible decrease took place in both arteries and veins; in the veins first, then in the whole course of the larger arterial branches which soon became invisible, and not even the colourless globules could be detected in those vessels, which formerly appeared quite red and distinct to the naked eye. The contraction remained permanent for nearly ten minutes, during which the arteries in the neighbouring portion of the web acted briskly. A retrograde motion took place in the leading veins, from which the smaller ones were engorged, and became gradually congested; and when the circulation recommenced in the artery, it was by pulsations, propelling a small coagulum, and, as it were, forcing open the contracted calibre, until the current was more or less generally restored. On its restoration, the blood took its due course in the larger veins, and the reticular veins, where they remained not totally congested, were much enlarged in diameter, with the blood circulating slowly; the arteries were also more enlarged than what was natural, and the velocity of the blood was more measurable. After having produced two or three repeated contractions, but none of which were so perfect as the first; the reflective phlogosis run on to complete congestion, and even to engorgement of the capillary arteries. On the other foot of the same frog, the arterial contraction after the application of Aq. Ammon. was so strong in a large leading branch, that the return of the circulation was despaired of; but the saturated salt solution, in a short time, made the vessel visible, and quick and deep congestion in the reticular veins was at the same time produced. Congested capillary veins, and a quick circulation in the larger capillary arteries, were often observed.

Exp. 7.—On the above frog subjected to experiment, on the following day.—All the above phenomena were nearly observed; the contractions of the vessels were sooner produced, and relaxation was sooner followed by congestion and inflammation. Contractions were produced twice perfectly in one artery; the veins always were relaxed first; and were at first retrogradely filled by the renovated arteries, making short cuts to the larger capillary veins. Diminished velocity or congestion of blood, with enlarged diameters, invariably commenced in the capillary veins, and accompanied every degree of the turgescent and reddened state of the part.

Exp. 8.—On a frog.—The application of Ol. Terebinth. was followed, without any notable immediate contraction, by an increased phlogosis of the web. The circulation, for a short time, became brisker in all the vessels; the reticular ones, however, were enlarged, according to the distance of time from the application. For five minutes, no congestion appeared, but in the course of ten, it was seen first in the reticular veins, afterwards in the next order of veins to them; then a sluggish motion was seen in the larger veins; next a diminished velocity with enlarged diameters in the arteries; and ultimately congestion or impaction of blood was observed in the capillary arteries, and which retrograded to the leading arteries of the web, until general stagnation took place.

Exp. 9.—On a frog.—The phenomena in this experiment showed nothing materially different from the last.

Exp. 10. On a frog.—Exhibited the same phenomena, only contraction of the vessels was not so palpably produced by Aq. Ammon.; owing, I make no doubt, to the diminished strength and vitality of the animal, which had been kept for

several days. One very remarkable appearance was observed in one of the webs previously untouched; namely, an ulcer with a margin beset with much phlogosis and inflammation. On being brought to the microscope, the inflamed circle was observed to consist chiefly of enlarged capillary veins, the blood in which was circulating very sluggishly, but was no where stagnant; the rest of the web seemed in a natural state of circulation, and no red blood elsewhere visible, except in the leading veins. On the application of Ol. Terebinth. the vessels soon put on a fuller circulation; all the capillaries became open for the red blood, which circulated briskly; but, at the same time, the current in the vessels round the ulcers became more and more sluggish, until complete congestion formed all round the margin. The capillary veins, as they were more distant from the ulcer, retained more of the general activity of the web, until the whole fell into complete congestion.

The parts thus run into complete congestion were, the following day, found entirely bereft of blood; no circulation could be detected, and the web was transparent and without colour, which no stimulus could restore, though the animal was still alive but weaker.

Exp. 11.—The web of the foot of a stout frog, which was kept in a little water for ten days, was seen under the microscope, in full circulation through all the classes of vessels, though the velocity of the blood was not so great or so lively as was seen in others, which were not so long confined. Capillary velocity always less in the veins than in the arteries, from which these vessels were supplied. Aq. Ammon. was once applied, and, in five minutes, the leading arteries began to contract irregularly, and where the contraction was greatest, the velocity was quickest. In half a minute longer, the whole artery became constricted, and no red blood or colour-

less fluid could be observed to circulate in it; and from being an artery quite visible to the naked eye, it became invisible, except as a fine line under the microscope. The veins afterwards gradually diminished in diameter until they were reduced to about two-thirds of their former calibre, with scarcely any blood circulating in them, from the supply being cut off by the contracted artery. The paleness and absence of blood were plainly occasioned by contracted vessels, and not from an independent recession or repulsion of the blood itself. In the space of five to ten minutes, the artery again enlarged, by faint propulsions from the trunk of the vessel next the toes, and it by degrees acquired all its former diameter and full circulation; becoming also, in a short time, more vascular and full than before the application of the Aq. Ammon. The capillary vessels were observed in this, as in other experiments, to be nearly of one uniform size, were disposed in meshes or net-work, and branched off in polygonal areas approaching to the square form.

Exp. 12.—On the web of a young duck's foot.—One leading arterial branch was first treated with several drops of alkohol; no immediate change of the apparent diameter of the vessels was observable by a small magnifying glass, but in half a minute, the whole of the vessels became evidently enlarged; the vessels in the other part of the web remaining in their natural condition. Aq. Ammon. was next applied; a very evanescent diminution of the size of the vessels was followed by increased turgescence.

The web of the other foot was pricked with a needle in the close vicinity of the leading vessel; a momentary contraction of its calibre, or a recession of the blood was followed by a relative increased expansion to what it previously had, before being wounded—cold, or apparent terror, produced the greatest contraction. Argent. Nit. was applied to a distant

branch of the vessel in the web, previously unexperimented upon; after momentary contraction, it was followed by great and turgid phlogosis of that part of the vessel, while the same branch nearer the trunk remained somewhat more than naturally constricted. Some other stimulants were applied, but heat produced the greatest expansion, almost rendering the capillary vessels double in their diameters. A pointed piece of Potass. Pur. was gently pressed on a branch of one of the vessels of the web, for about twenty seconds; the part touched was then seen greatly distended with red blood, and the diameter of the vessel much and palpably enlarged, while the continuation of the same nearer the trunk was evidently contracted, until it became almost invisible. The cauterized portion remained gorged, stagnant, and lost its vitality—the blood gradually becoming black. The contracted part apparently became obliterated, until it joined the next ramula, about half an inch distant; and it remained so for fifteen minutes, when it grew just visible, nearly as far as the eschar. The capillaries around the eschar became flushed, and the little branches beyond it, which were formerly supplied by the now obstructed artery, became redder, more full, and some new ones were rendered visible,—all apparently fed by surrounding anastomoses.

Exp. 13.—On a frog.—The vessels of the web were observed in full circulation, immediately before the animal was fastened for the experiment, by nooses of thread carefully, but not tightly, put round its limbs, and run through holes in a piece of pasteboard. The chest was opened by the scissors, the pericardium slit up, and a ligature quickly put by the tenaculum round the great vessels of the heart. The web was instantly examined by the microscope; no circulation, but a few pulsatory motions, were seen in the arteries; and in the veins, a slow and retrograde current was only obser-

ved. Continued inspection detected no increase of circulation, though the animal was in full muscular play. Some minutes before the animal died, the mesentery was brought to the microscope, but nothing but a languid and retrograde motion could be observed in the veins.

Exp. 14.—On a frog, fastened in a similar manner. The thorax was quickly opened, just to admit the application of the ligature, in the manner above-mentioned, without a wound of any vessel. Inspection of the web was immediate; but from being previously in full circulation, and approaching to inflammation, it was now become quite pale and exsanguious; and the only circulation, that could be detected, was a faint undulatory and rather retrograde motion in the veins, which neither time nor stimuli could further revive, though the animal continued long to struggle violently. The heart was still and contracted, but on loosing the ligature around its base, and allowing it to feel the tide of blood, it began slowly to fill, and contracted for nearly two minutes, but no circulation could again be discovered in the web of the foot, and but a very languid recession of the blood was observed in the web of the mesentery.

It would have been very desirable to have extended similar experiments on the living tissues of the above, or any other animals, which could afford an insight into the circulation, or the relative habitudes of the blood-vessels; but, for the reason already alluded to, this research was necessarily relinquished for an indefinite time.

Few and simple as these experiments are, yet, as they afford a series of phenomena, of so little

essential difference, and involving no point of dissimilitude, but what their slight variety of circumstances would explain; it is to be presumed, that even a farther extension of them, especially on the same animals and tissues, would not have presented any contradictory results. Taking them, then, as an insulated detachment of experiments, and without at present alluding to what has been already deduced by others, from similar researches on the same class of animals, the corollaries, that appear to me to be deducible from the whole of them, are the following:

First. The greater part of the capillary blood-vessels are distributed in a reticular manner, the innumerable meshes of which chiefly affect the quadrangular form; and this tissue is principally composed of veins, and is intersected and supplied by more linear capillary arteries.

Second. The more natural and undisturbed the circulation, and the stronger the animal, the greater is the velocity of the blood; except sometimes immediately after the application of a comparatively slight stimulus, which increases the circulation a little.

Third. The healthy and natural circulation in the capillaries depends, directly, on a tonic or *tensive* state of their delicate tubes; and mediately, on some power inherent in the part, a degree of which power seems to reside in the blood equally with the vessels, and its energy depends more on the integrity or vitality of the

part or parts of this system, than upon any impulse derived from the heart.

Fourth. The effects of a stimulus are according to the length or intensity of the application; and as regards the vessels to which it is applied, they are proportioned to the vitality of the part, and to the pressure of the column of blood in the leading arteries.

Fifth. A strong stimulus suddenly applied, in a short time, produces a contraction of all the fibres of the part, and a diminution of the diameters of the whole classes of vessels, but more particularly of the arteries, which is followed, at a greater or less distance of time, by a corresponding dilatation---according to the extent of which, the phenomena of inflammation will be more or less observable; and more so, if the *vis a tergo* be powerful or stimulated.

Sixth. A gentle or lesser stimulus produces an evanescent contraction, followed by relaxation, increased redness, and a slight acceleration of blood in the *leading* capillary arteries and veins; owing, it seems, to the increased capacity of the distended reticular vessels, while the former are yet relatively contracted.

Seventh. The circulation in the capillary system is independent of the controul of the heart, except so far as this organ affords a constant pressure and a ready supply of blood, upon which the capillary vessels may act; and it is still more independent of the brain.

Eighth. There are three states, in which the capil-

lary system may be situated, the more perfect degrees of which are, 1st, an *atonic* or *collapsed* condition of the vessels, wherein no circulation takes place, nor can red blood be observable, but the return of both which can be more or less easily accomplished. 2dly, The *tonic*, or *tensive* state, which is the natural one, and wherein the circulation is brisk, uniform, and capable of being slightly accelerated by heat and moderate stimuli. The 3d is the *turgid*, *distended*, or *congested* state, wherein the blood has a diminished velocity; but if dilatation has not reached a certain point, contraction and a quicker circulation can be restored. This last condition is a species of atony opposite to the first—both, however, depending on weakness or exhaustion in the part, but with a different contingency of the *vis a tergo*, or the pressure of blood from the larger arteries.

Ninth. The *vis a tergo* being a constant force, the velocity of the blood is inversely as the diameters of any set of vessels, compared with the capacities of those, which immediately succeed them—thus congested capillary veins and a quick circulation in the larger capillary arteries are quite compatible.

Tenth. The condition of a part, in what is termed inflammation, is essentially seated in the capillary vessels, and primarily and chiefly in those of the veins.

Eleventh. Inflammation and congestion affect a portion of the capillary tissue, more from a local or topi-

cal condition, than from any action communicated by the vessels leading to the part.

Twelfth. Congested and even stagnant blood may be brought again into circulation; while a part, that has been deeply inflamed, or turgescent, in a short time, may be found pale, flaccid, and collapsed, in a dying animal.

Before deducing any further physiological or pathological argument from these few experiments, conjoined with those which have been more fully instituted by others; it may be proper, previously to notice the results of the more extended researches of some of our first physiologists, and to see what inferences they have drawn on the subject. In extent, arrangement, and clearness, nothing of the kind has yet equalled the two *Memoires* of Haller; but as the experiments were all instituted for the purpose of enquiring into the natural circulation of the blood, through the whole circle of the body, he has chosen to make them available only to physiological conclusions. His experiments on the capillary class of vessels are many, varied, and beautiful, and all tend to show the independent action of this system, as to the circulation of its contained blood. The various phenomena, which he witnessed, led him to attribute this automatic movement of the blood to four several causes, the first of which he calls *dérivation*, and is the cause, by which the blood runs to the part, where there is the least resistance; and he cites the flow of blood in ar-

teriotomy and venesection in the living animal, even where the heart is incarcerated or cut out, as proofs of the existence of this cause. This force he places superior to that of gravity. The second cause, according to him, is *gravity*, which he observed to take place in the living animal, without any regard to the natural direction of the circulation. The third cause, he calls *attraction*, because he observed the blood to be attracted by the membranes of the living fibre, and towards *un objet non contigu*, which appears to influence it; this cause also acts upon the globules themselves, which are always attracted to their own masses, similar to the globules of mercury. He only uses the term attraction, without pretending to penetrate into the cause; and he says, *que je serois charmé d' apprendre*. His fourth cause, he terms, nervous irritation, *l'irritation nerveuse*, which is also independent of the heart. This cause he has seen to act, when the blood was restored to motion, by an irritation or concussion.

He lastly sums up this enumeration of causes, by saying, "*La suction vaisseaux capillaires*, n'est point " confirmée par mes expériences. Le sang est attiré " aussi souvent dans les troncs des vaisseaux, qu'il l'est " dans les branches, quand on a détruit le cœur : ce qui " est entiérement contraire a l'idee d'une force, qui " attireroit le sang dans les vaisseaux capillaires. Il se- " roit aisé d'ailleurs de faire voir, qu'une force pareille " detruiroit la circulation, en retenant dans ces vais-

"seaux le sang, qui en doit sortir, pour revenir au "cœur."*

It would have been desirable that a more complete verification could have been obtained of the actual condition of the capillary arteries, when they contain varying columns of blood. In the limited experiments above described, a diminshed column had every appearance of being accompanied with a contraction of the periphery of the artery; for the lessened column was defined in its line, and consisted of one or more globules in the area of the section, in close and linear succession to one another. Haller, however, denied all contraction or dilatation to the capillary arteries and veins,† and says, the appearance of either of these conditions, depends not on the gross diameter of the vessel being relatively dilated or constricted, but only on the calibre (*la lumiere*) of the artery becoming enlarged in its state of turgescence, while the tunics of the vessel are in the same ratio condensed; and that in apparent contraction, the same tunics are increased in thickness, as the column of the blood is diminished in diameter. He moreover seems to think that this change of thickness of the arterial membranes was a new discovery.‡

That in the smallest capillaries, such a recession of the blood takes place, as to leave the vessels in a more or less empty state, is quite observable, as has been

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* *Deux Memoires*, p. 336, ad finem. † *Ibid.* p. 236.

‡ *Ibid.* p. 328.

remarked in the eighth corollary, and which is noted as one of the three states of the capillary system ; but that the larger capillary arteries, admitting from three to six globules in their transverse diameters, do not suffer contraction or distension of their whole tunics, from the application of cold, heat, and chemical stimuli, is what many physiological experiments render questionable, and even far from doubtful. If, however, Haller admitted that the internal tunic is subject to be expanded, and to be diminished in its calibre, it is, perhaps, of little consequence, whether the outer membranes of the vessels were thought to be similarly and consentaneously affected, as the surface next the blood must represent the true recipient tunic. The immediate cause of this diminution of the calibre of the vessel, would, according to this great physiologist, be attributed to a relaxation of the inner membrane, allowing its sides to approximate, and that this obtains the more, the more the part or the animal is debilitated. When again the vigor of the circulation is increased, the calibre augments, and a condensation or contraction takes place, in the membranous coats themselves, while the absolute diameter of the whole is not in either case altered. Without venturing to decide upon the exact nature of these two conditions of the vessels, I have classed similarly observed phenomena in the reticular vessels, under the respective states of *collapse* and *tensiveness;* without excluding the property of contraction, on the application of stimuli, to be inhe-

rent in the larger capillaries, and more especially in the arteries, when these vessels are not too far distended, nor have lost their organic recovery. Though Haller often witnessed the venous part of the capillary plexus to be greatly engorged, and the blood in slow circulation, while the arteries, few in number, were conveying the blood with great velocity through the part; yet he did not take particular notice of this engorged or inflamed state of the vessels, nor speculated on its immediate cause---whether it was the result of an undue *vis a tergo*, or an atony of the vessels affected. He was one of the strongest advocates for the great irritability of the heart; but, except in what he alludes to in his *l'irritation nerveuse*, as one of the several causes of capillary motion, he does not assign any property of this kind to the capillary vessels, equal to what some physiologists since, from conclusive experiments, have done.

As to the diminished velocity of the blood observing the ratio of the decreasing diameters of the vessels and their distance from the heart, as has been propounded on the hydraulic theory of the circulation, Haller often found the blood to move as quick, and sometimes quicker in the capillary net-work, than it did in the larger arteries and veins,*---clearly showing, that the efficient cause of the blood's motion, in this system of vessels, depended on some automatic power resident in

* *Deux Mem.* p. 262.

the part itself, consisting visibly of only cellular tissue, vessels and blood.

The last section of experiments which Haller details in his *Memoires*, was instituted to ascertain more precisely the nature of the circulation, when the vessels are deprived of the motive action of the heart, either by section of the great vessels, incarceration by ligature, or amputation of this organ. However triumphantly experiments of this kind have been brought forward, in proof of the vascular independence of the capillary circulation, out of forty-one experiments, he describes only one, where the circulation in the capillary *plexus* remained after the two branches of the aorta were cut across, and this continued for the space of ten minutes only. In all the others, the arterial circulation was either instantly arrested, on the insulation of the heart, or else it was vacillating or retrograde, while the extreme capillary movement was stopped. The veins, which preserved the greatest movement of the blood, and for the longest period, after the central organ was neutralized, also exhibited, in the majority of instances, currents of blood, as often in the retrograde, as in the natural order of circulation; and in all the experiments, the blood is not noticed, as having continued in its natural current for any given time, through all the orders of vessels, though mention is repeatedly made of the circulation being in universal play, previous to the several experiments. The one instance of the circulation remaining perfect

in the capillary *plexus*, after section of the aorta, may be considered, as affording sufficient proof of the physiological fact; but otherwise, some consideration would undoubtedly have been due to the negative instances, in any argument founded solely on the experiments of Haller. The two experiments above detailed, No. 13 and 14, coincide generally with the phenomena observed in 40 of Haller's, and the solitary one mentioned by him, of the circulation in *le reseau veineux* surviving the motive aid of the heart, remains to be weighed, in physiological data, with the general phenomena, or with others that may be hereafter noticed.

On the circulation of the blood the opinions of John Hunter are too well known to require any detailed exposition here.* To all the medical world, he is known, to have attributed the primary moving power to the heart, and that the contractions of the arteries carried on the current of the blood, and acted in consecutive co-operation with the central organ of circulation. Without revising his alleged proofs, and his ingenious illustrations on this now amply discussed portion of physiology, I shall merely collect what he has remarked on the capillary system, though he does not seem to have made it a subject of much extended or exclusive experiment. The capillary vessels appeared to him be "almost entirely muscular,† and

* *Hunter on the Blood, Inflammation, &c.* 2 vol. London, 1813.

† *Ibid.* p. 207.

totally " devoid of elasticity ;" the elastic coat of the leading arteries not extending into this system of vessels. He again, qualifies this by supposing, " that " no vessel, even to its very extremity, is ever entirely " collapsed, but that it possesses an elastic power suffi- " cient to give it a middle state,"* namely, between impervious contraction and relaxation. His opinion of the important part, which the contraction of arteries performed, was much confirmed by observing that in animals, whose arteries were very muscular, the heart was proportionably smaller, and *vice versa*. This would be a very great corroboration indeed, if such observations were generally noticed, but I do not at present remember how far they have been witnessed by other physiologists. Indeed, Mr. Hunter himself, in another place, to avoid perhaps some difficulties in this theory of muscularity, says, that the circulation in a palsied limb, may, in some measure be ascribed to the " involuntary nervous power." The principal part wherein he recognizes an independent power in the blood-vessels, is, where he says, they have " a power " of increase within themselves, both in diameter " and in length ;"† but as this faculty is applied by him chiefly to the larger vessels, in consonance with his doctrine of inflammation, it may be said not to be strictly characteristic of the capillary system. According to him, when they enlarge in health, it is

* *Hunter on the Blood, Inflam. &c* 2 vol. p. 213. † *Ibid.* p. 276.

from the "stimulus of necessity," and when in disease, it is from irritation. His illustration of this last property, from the application of the caustic to a patient's toe, might be brought to a different pathological conclusion, and has some affinity with the application of stimulants in some of the above experiments.

His observations upon the anastomoses of vessels apply in a great measure to what is strictly called the capillary net-work, though he does not point out its very separate conformation from the rest of the blood vessels; and though he chiefly considers the anastomoses as subservient to counteract any obstructions in the contiguous vessels, and to facilitate a more ready return of the blood, yet, he conjectures, that "all the "uses arising from the anastomosing of the vessels, "are not yet perfectly understood."

He supposes "the capillary arteries in the fœtus to "be as numerous as in the adult, and perhaps more so," and the smallest vessels to be nearly the same size in both. The velocity of the blood in the small vessels he considers to be much less than the large ones, being diminished by the angles of distribution and the numerous anastomoses, as well as by the increased capacity of the branches, compared with the trunks of the vessels. He ascribes muscularity and elasticity to the veins, though in a less degree than to the arteries; and says, "their strength is in an inverse ratio to "their size in the extremities."

To take our present leave of this eminent man, he

appears to have fully satisfied himself as to the independent nature of the blood-vessels, though he extends this independence to a much more active influence on the circulation in the large vessels, than others since have allowed; and he is completely at issue with Parry and others on the subject of the dilatation and contraction of the arteries. It is very curious, however, to see how experiments, more strictly examined, tend to reconcile the different opinions and inferences, which have been drawn by different observers; and the experiments of Dr. Parry certainly receive much elucidation from the following observations of Mr. Hunter, who says, "Arteries during their diastole, increase "much more in length than width, being thrown into "a serpentine course." "It is, however, the increased "diameter that becomes sensible to the touch. The "dilatation of the artery producing the stroke, is either "felt by the finger, or may be seen when superficial; "but were we to judge of the real increase of the ar-"tery by this, we should deceive ourselves; for when "covered by the integuments, the apparent effect is "much greater than it really is in the artery itself; "for in laying such an artery bare, the nearer we "come to it, the less vissible is its pulsation; and, *when* "*laid bare, its motion is hardly to be either felt or* "*seen!*"*

Haller's idea of the relaxation of the inner mem-

* *Hunter on the Blood, Inflammation, &c.* p. 307.

brane of the capillaries, when they exhibit a languid or debilitated circulation, is somewhat confirmed though with a different physiological inference, by the observation of Mr. Hunter, "that when the smaller "arteries are slit up, they are found to be beset with "*rugæ* or wrinkles, which are principally longitu- "dinal."*

The experiments of Spallanzani,† on the blood in frogs, salamanders, tadpoles, and incubated eggs almost generally agree with those of Haller, and the observations made, do not differ in any material degree, from those of the Baron's, on the nature of capillary circulation. The Abbè observed the motion of the blood to be rapid, and of nearly equal velocity in those animals, whose strength was not impaired, and to become oscillatory, intermittent, and pulsatory, according to the diminished power of the heart, and the weakness of the animal. The heart then appeared to have a direct motive power on the smaller, as well as on the larger arteries, and even on the veins. He saw arteries that admitted only one red globule in their transverse diameter, while some, at their termination in veins, contained five globules in the transverse section. The relative diminished velocity of the blood, in any class of vessels, seemed to him to de-

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* *Hunter on the Blood, Inflammation, &c.* p. 210.

† *Experiments on the Circulation of the Blood, &c. &c,* by Abbè Spallanzani, translated by Dr. Hall, M. D. 1801.

pend on the enlarged diameters of the vessels, either apart, or in the aggregate. He supposed a complete *inertia* in the coats of the capillary veins, and a retardation of velocity in the circulation through them: with Parry, was of opinion, that the course of the blood is independent of the contraction of the arteries, the very largest of which only shewed a degree of *it*; and in embryos, no contraction or dilatation could be perceived throughout the whole vascular system. The red globules appeared to him to be borne along by a kind of invisible gas, and that they are elastic in their nature, from their appearing to be enlarged and diminished during the course of experiment.

From the result of a very extended set of experiments,* though not severally detailed, Dr. Thomson was fully confirmed in the doctrine of the independent irritability of the capillary arteries; and by a severer scrutiny of the habitudes of these vessels, under various applications, than what Haller subjected them to, he observed in the majority of trials, that the arteries are not, in any of their coats, as "*de tuyaux de verre*," according to what Haller conceived, but that they are possessed of a vital contractility, altogether independent of the heart, and even of the contiguous state of the neighbouring vessels of the part or limb. It is always to be regretted, when the experiments of eminent and trust-worthy men do not agree more fre-

* Dr. Thomson's *Lectures on Inflammation, &c.* Edin. 1813.

quently in their results; and this confirmation of the contractile power of the capillary arteries, is a very important difference from Haller's observations, for on it depends, very essentially, some of the first pathological inductions.

In forming any comparative estimate of the respective value of experiments made on the capillary system, a due distinction must always be observed, when mention is made of the vessels, whether the reticular plexus, or the leading capillary branches are meant, or made the subject of any deduction. Contraction in the former class, whether of arteries or veins, is not a matter nearly of such definite observation as it is in the latter. In these it is easily produced by stimulant applications; but in the extreme net-work, the contractility is more inferred from an absence or decrease of red blood, and of a less observable velocity, owing sometimes to its quickness, than from the appearance of any defined contractions in the diameters of these minute vessels. Collapse, tension, and dilatation, as has been noticed, are more particularly applicable to the respective states of this part of the system, than to the leading branches of it. Dr. Thomson's experiments allow much latitude of deductive reasoning in some other respects, though they are defined and precise, as to the independent contractility of the capillary arteries; for he observed, that the velocity of the blood may be either increased, diminished, or stopped, with an enlargement of the diameters of the

blood-vessels.* A few of the principal phenomena he observed were these: the general circulation through the webs of frogs' feet was increased on the application of Alkohol, without any perceptible change in the diameters of the vessels: "Weak volatile Alkali, "or Ammonia, produced, in many instances, a com- "plete contraction of the arteries, to which it was more "immediately applied;" "and this successively for "four times, at intervals of four or five minutes:" the "most remarkable effect from the contraction of the ar- "tery, was a diminution of the velocity of the circula- "tion in the capillary vessels, supplied by the contract- "ing artery." Irritation by a needle produced contraction of the smaller arteries, which irritation always increased the general circulation through the web;—the application of a solution of salt was followed, very soon, by "actual and sensible" dilatation of the capillary arteries; and in nine experiments with this application, "a sensible enlargement of the arterial and "venous branches, was accompanied by an increased "rapidity of circulation in the capillary vessels,"—repeated application was followed, however, by retarded or stagnated blood in the capillaries. "Another "result from the solution was, an apparent increase of "circulation in the arteries and veins, with a diminu- "tion of velocity in the capillary branches," but the most frequent result was diminished velocity of the

* *Lectures on Inflammation*, p. 37.

circulation in all arteries, veins, and capillaries. He also, "in no one experiment, perceived any enlarge-"ment of an artery during the momentary influx of "blood into its canal." The inferences to which Dr. Thomson has applied his experiments, were confined to the nature of these several orders of vessels, as they were affected in inflammation; and however unrestricted and undefined they appear to be, as to the precise nature of that affection, so far as the increased or diminished velocity of the blood is alone concerned, they yet throw much light on the doctrines which inflammation essentially involves.

To Dr. Wilson Philip we are indebted for the largest experimental inquiry, that has been instituted into the laws of the vital and moving powers of the nerves and blood-vessels; and the nature and properties of capillary circulation have received from him, some of its most instructive elucidation.* He has fully confirmed the circulation of the capillary vessels to be independent of the action of the heart, and has shewn, that it may be directly impeded or arrested, by a general injury of the nervous system of the brain and spinal marrow: while he found it to continue unimpaired, for many minutes, after the action of the heart had been completely neutralized, by excision or incarceration of that organ. He considers the motive action of the blood-vessels to bear the same relation to the nervous

* *An Exper. Inq. into the Laws of the Vital Func.* 2d Ed. 1818.

system, which the excitability of the heart itself does, and consequently, that its properties are the same in kind, as those which give the heart its automatic power. Another important property he discovered in the vessels, and that was, the circulation being retarded and stopped by the application of sedatives, as solutions of tobacco, to the body, brain, and limb; while the washing of the same off the part, renewed the circulation, which still became much more vigorous from the application of spirits of wine:—all tending to shew, that the effects of some sedatives are direct, and not in consequence of previous exhausted action or impaired irritability. He was fully satisfied, that experiments on cold-blooded animals, are quite available to any inferences, that may legitimately be made, as to the physiology of warm-blooded ones; for he observed the circulation in the mesentery of rabbits to exhibit the same phenomena, as the capillary vessels of the frog did, in similarly conducted experiments. What is nearly allied to that state of the capillaries, I have termed *collapse*, is his observation of the circulation failing, without any morbid distension of the vessels; while morbid distension, giving rise to the phenomena of inflammation, and proceeding until the motion of the blood ceases altogether, is the condition before noticed as the other species of capillary atony.

Dr. Philip in the 62d experiment of his "Inquiry" seems to have more than sufficiently verified the circulation of the capillary vessels to be independent of the

heart, for in the mesentery of the rabbit, that had been dead one hour and a quarter, the blood in the capillaries was found by him to be moving freely. Perhaps the physiolgical fact did not require this extent of proof, which far exceeds any thing, which Haller could detect in the course of forty experiments. Though facts of this importance cannot be too much confirmed; yet it is quite satisfactory and ample in its proof, for all purposes of physiological reasoning, to be assured, that in the living animal, the capillary system can be made to contract, quicken or retard its circulation, and to suffer distension, without the direct motive influence of the heart; and above all, the circulation continuing in the capillarics, for any time whatever, after the heart has been excised, is as much exact proof, as is wanted for the above purposes. With the limited proof I have remained satisfied, as the experiments, which I attempted for a more ample one, were not so conclusive as I could have wished. In this experiment of Dr. Philip, when we consider the time, during which the animal was dead, and that the intestines were hanging through a wound in the parietes of the abdomen, and not in *situ;* and also that the mesentery had been "long quite cold," some part of the circulation observed may surely be attributed to position, motion, and mechanical collapse of the solids of the body, operating on elastic tubes:—besides, is there nothing due to the remaining vitality of the blood itself?

It may here be remarked, that some of the impos-

ing experiments of modern research are not altogether free from occasional fallacy. In very few of them is the natural play of the functions left so undisturbed, as to present the physiological fact, naked, and uninfluenced by the contingent and necessary injury to the animal. The excision of the heart, crushing of the brain, and comminution of the spinal marrow, are lesions of such extent and severity, that it is next to an imposibility, that any department of the living functions can retain any natural integrity, and be of sufficient precision, as to give an unvitiated index of the spontaneous machinery of life. These experiments may, and do verify some of the grosser principles of the vital function, but the inferences drawn from them must be applied, with some caution, to the more intimate nature of the functions in health and disease. That the circulation can be upheld, abstractedly considered, without either a heart or a brain, we do not, it must be confessed, require the forced demonstration of decapitated animals, or of their amputated hearts. The rudiments of the chick *in ovo*, the circulation of the portal vein, some acephalous fœtuses, and animals which lived to the adult state with ossified brain,* might, perhaps, be reckoned confirmatory enough of the physiological possibility. It is of more importance to know the reciprocal action of all the functions in healthy animals,

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* *An Inquiry into the Vital and Animal Actions, &c.* by T. Simson, M. D. Edin. 1752.

and the nature of those intimate lesions of structure and of function, which, at first, are either overlooked, or they escape our observation from their impalpableness or evanescence, till the frame or part has suffered a cognizable and important injury.

But to resume the subject of the capillary system, and before any farther conclusions are drawn from what has been shewn and verified by the experiments and researches above detailed ; it may be useful to inquire, what assistance our knowledge of what is called the principle of vitality, or of that power by which the capillaries act, independent of the heart or brain, can legitimately avail us, in the more extended consideration of capillary phenomena.

This is a part of the analytical process, into which, it behoves young inquirers to enter with circumspection; for in the present state of physiology, we may here, in speculation, let slip the pen, which thus far has been guided by facts and observation. Without, however, losing hold of the ground of our analysis, as far as this subject is susceptible, we may be fairly allowed to reason on those properties of this principle, which are palpable to our senses ; and what has been allowed to Newton in his doctrine of gravity, as a principle of inanimate matter, may, with nearly equal fairness, be granted to the physiologist in his reasonings on the principle of life. That a muscle contracts when irritated, in the living and in the recently dead animal ; and that the capillary vessels, under certain irritations,

also enlarge and diminish in their diameters, with corresponding alterations in the velocity and in the volume of the blood circulating through them, without either the heart, brain, or spinal marrow influencing, or sympathizing in, the local affection, are facts, which experiment has fully confirmed. The question is, what are the nature, properties, and extent of that power, by which these effects of irritation or stimulation are produced.

Without speculating on the exact nature of this power, whether it is the result of organization, or that it is a principle superadded to it, the questions about which have been so often agitated by psychologists and materialists; it is quite sufficient for the present inquiry, and more conformable to the inductive rules, which it has been endeavoured to follow, simply to embody and define the cognizable properties of this principle, which are as obvious in their phenomena, as the principle itself is obscure and illusory in its origin. From the experiments and observations of Haller, Hunter, Bichât, Le Gallois, Philip, and other physiologists; and which may be confirmed, to the general import, by any, who will devote some research to the subject, it appears, that this inherent principle of the living body is resident in every part of the system, in absolute quantities, or in forces, proportioned to the health, strength, and perfection of the individual. It is found, to pervade, with an extent more or less equal, the whole structures of the body, with the exception, perhaps, of the hair and the

extreme horny textures; but it more particularly is attached to, or resides in greater quantity or force in the muscular fibres, wherever situated. Of the vital organs, it resides more in the heart, than in the brain or spinal marrow, in which two last, it is probable, the meninges are its chief seat; and the stomach appears to contain the most variable quantities, and to part with it, with a corresponding facility, and in a ratio to the rapidity or the severity of an injury.

Its very peculiar property, is its local as well as its general independence; existing before the sensation or volition of the animal, preserving through life this independent though not uncontrolable gift of nature, and lastly outliving the entire dissolution of the above faculties. In other words, the parts, endued with this principle, perform their functions or answer to natural or artificial impressions, independent of the nervous power, or of that influence which emanates from the brain and spinal marrow, though they are subject to its control. Parts similarly endued are also independent of each other, in their offices and capabilities; as the heart is of the stomach, the blood-vessels of the heart, and the several sections of the blood-vessels of each other. The blood itself seems also possessed of a portion of this principle, how far independent of the vessels or any part of them, in which it circulates, is not yet fully ascertained; but to the limited length of my observations, I am inclined to think, that its degree of vitality, at any time, is in some

near proportion to that of the vessels in which, at the time, it is contained. There is still further reason to think, that what of this vital principle, the blood may lose or acquire in any part of its circuit, it may regain or part with, in some other segment of the circulation; without reckoning on the constant supply, which it may acquire of this principle in the lungs and the heart.

This primary principle of animal life has received different appellations, according to the preconceived theory, or the more cautious or correct notions of the observer. It seems to be allied to the *vita vegetativa* of the ancients, the *Archeus* of Helmont, and to the seat of the celebrated *Vis Medicatrix*, and to be the *Irritability* of Haller, the *Sensorial Power of Irritation* of Darwin, the *Principe de la Vie* and *Organic Life* of the French, the *Materia vitæ diffusa* of Hunter, and the *Muscular Power* of Dr. Philip and some others; which last term makes it sufficiently distinguishable from the other powers of the more perfect living animal.

The most obvious property, by which this principle is manifested, is that of contractility of all fibres having a muscular structure or character; a lesser visible degree of the same power, is a state of tensiveness affecting the same structures. These phenomena of contraction and tensiveness obtain, not only in the muscular textures, commonly so called, but also in the more attenuated structures and membranes, such as the capillary blood-vessels; and there is every reason,

from limited proof, to believe, that some degree of them affects the red globules of the blood itself, under the influence of appropriate stimuli.* How far this principle can ever absolutely accumulate to an excess, beyond what is necessary to the perfect integrity of all the functions and parts, and to the prejudice of health, I will not venture to determine; but that its relative deficiency or lesion in any part, organ, or in the body in general, is essentially connected with derangement or disease, there can be no doubt. Confining the elucidation to the latter subject, this *minus* state of the vital principle or muscular power can be produced, or takes place, in the capillary system, in two ways; first, from cold being long applied, poison, some sedatives, want of nutrition in the blood, and by the infliction of severe external injury: and secondly, it is produced by the too frequent application of moderate stimuli, or by the sudden operation of stronger ones. The consequences of this negative state, in whichever of these modes produced, are, relaxation of all the tissues, softness of the ambient muscles, and collapse or atonic distension of the capillary vessels; the strength or weakness of the

* In some of the experiments, which I instituted on the circulation in frogs, the globules, during the natural or quick circulation, appeared smaller, than when they were retarded in the vessels; and when they, at any time, became congested or stagnant, they severally appeared to swell and to become less cohesive, until they sometimes turned paler, and, as it were, dissolved in the intermingled serum.

vis a tergo determining which of these vascular conditions will take place. It appears, also, from experiment* that this property can be excited, or rendered more demonstrable, by stimuli applied to the roots or the course of the nerves distributed to the part, which appear to be only the conductors of impressions; while the same phenomena of contraction and tensiveness, in both muscles and vessels, can be elicited by stimuli applied directly to the part itself, after the nerves of conduction are cut across, and all nervous communication between the brain, spine, and heart is intercepted. This is a very important physiological fact, and forcibly serves to explain many of the collateral phenomena of disease; such as the circulation continuing in a palsied limb, or through the body in a fit of apoplexy. Indeed the contraction and dilatation of the heart occuring, for some time, after it has been excised from the body, is as demonstrative of the independence of its action, as any thing possibly can be in physiology; and shews, that neither the brain nor the nerves are the immediate origin of its motive powers.

Though Dr. Philip seems fully of opinion, that secretion depends on the nervous, and not on the muscular power, or the irritability of the organ; but only, that the vessels convey the blood to be operated upon by the supposed secreting power of the nervous system:† yet, it is not easily seen, in this case, how any perspiration

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* *Philip's Exp. Inq. on the Vital Func.* ch. 2 & 3. † *Idem*, p. 128.

can take place in paralysis, or that pus can be formed in the ulcers of a palsied limb. These secretions, though imperfectly performed, might, with as much strictness of induction, be attributed to the unexcited irritability of the limb, to which power secretion in general may always independently be owing; subject to the wholesome excitations, which, in a state of health, are conveyed through the nerves. Besides, it is certainly creating a division of labor, which may appear unnecessary, to assign the muscular action of the stomach to the muscular power, and its function of secretion to the nerves, which are distributed to it; and with much deference to the deductions, which have been made by Dr. Philip, I am induced to consider, that his very ample experiments are quite as confirmatory of secretion being made to depend, in either the living or the recently dead animal, on the irritability of the organ or its muscular power, as they are of its dependence on the nervous influence. This influence, in life, appears to be the natural stimulus, and the nervous cords the channel of further stimulation, or of direct sedative influence; as galvanism proves to be an artificial stimulus to the muscular power, that may yet remain, to different extents, in the recently dead animal.

Leaving, however, at present the labors and analysis of this extensive inquirer to that high respect, to which they are entitled, and wishing to refrain from overstepping the strict boundary, prescribed in the outset of this short essay, for the indulgence of any curious

speculation into the manner, by which this principle of automatic or organic life is at first produced, and from time to time generated ; I shall also desist from speculating on the exact part or time, in which the food is at first endued with this principle ; and whether this vital power is of the nature of vegetative life or of electric matter ; or finally, how it is dissipated in the dying and in the dead animal. Without, then, attempting any inquiry into these most important subjects, however much assistance the opinions of others might afford for the undertaking ; it will be more consonant with the limited tenor of this dissertation, and within the line, it is presumed, of demonstrative physiology, to conclude by making this principle of animal life, an object of deduction and argument, only as it is exhibited in its sensible habitudes and properties—leaving to time and the accumulation of researches, the further elucidation and prosecution of this very interesting analysis.

Having stated thus much concerning this property of vitality, or what is called the muscular power by Dr. Philip, as considered more strictly by itself ; and having noticed the chief part of what has been ascertained by experiment on the capillary circulation, as an object of physiological observation : it will therefore not be an inappropiate, if it be not a conformable conclusion to the whole, to state the few remaining inferences, which may fairly be drawn from the collated facts and observations.

In the First place, then, it appears, that in the healthy and natural integrity of the capillary circulation, the blood is supplied by the propulsive action of the heart, in a constant reservoir of streams, which the capillary vessels feed upon, with an independent action ;—that the blood is transmitted through this system of vessels by a power, which is resident, in some degree, in the blood itself, as well as in the vessels ;—that this power is an inherent constituent of the part, including all its organizations, and may be said to be of the identical nature with the power, by which a muscle contracts, and the heart performs its constant functions :—and that the blood circulates through this system, in a uniform and brisk current, without pulsation or undulation ; and that the vessels are then in a *tensive* or an *erectile** state, suffering no distension from the blood, nor yet embracing their contents with any physical pressure or constriction.†

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* This state of the capillary vessels has been more than once noticed in the observations made in the Medico-Chirurgical Review, when noticing works on the circulation of the blood and inflammation, and the term *erectile* is very descriptive of the condition of these vessels in many of their phenomena ; but I have chosen the words, *tensive* and *tensiveness*, as terms, which appear to be of as much generic application in all the tissues of the body.

† " Les globules du sang ne roulent pas sur leur axe, ils " nagent avec regularité, et en parcourant des lignes droites le " long des vaisseaux : leur choc contre les parois des arteres ou

Secondly. The capillary system, strictly so called, may be at rest, or its action more or less generally suspended, and the circulation be yet continued through the heart and other blood-vessels, by the means of the anastomoses of the small leading arteries and veins,—and, on the contrary, the action of the heart and the circulation in the large vessels may be, for a time, arrested or destroyed, and yet the capillary circulation be continued. May not this *post-obit* property of these vessels remove many traces of inflammation, before the autopsical inspection of the suspected part can be accomplished ?

Thirdly. The collapsed state of the capillary vessels is not a vital constriction or spasm ; but is the effect of either a partial absence, suspension, or lesion of the due irritability or muscular power of the part, occasioned by either a local impression or injury, or by a severe general injury inflicted on the whole of the

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" contre les éperons de leurs divisions, n' a point de violence." *Haller's Deux Mèmoires*, p. 236.

If a speculation could be advanced, on the identity of the muscular or nervous power with the nature of electricity, the following phenomenon of capillary tubes might not be held unworthy of being taken, as some analogical proof. " When water is made " to pass through a capillary tube of such a bore, that the fluid is " discharged only in successive drops ; the tube, when electrified, " will furnish a constant and accelerated stream, and the acce- " leration is proportional to the smallness of the bore"—*Encyclop. Brit.* Art. Hydrodynamics.

brain or system, by concussion, wounds, blows, or sedatives ; and this collapsed state may also be produced, or be accompanied by a diminished action of the *vis a tergo* in the leading arteries.

Fourthly. The distended or congested state of the capillary vessels is the consequence, of either the too frequent, or the too powerful application of stimuli, exhausting the muscular power of the part,—the *vis a tergo* being in natural force or quantity ; or of this natural *vis a tergo* succeeding to, or attending a long or deeply collapsed condition of the capillaries : or it is more readily and remarkably produced, by either of these circumstances of the capillary vessels, being followed or attended by an excited, or a preternatural *vis a tergo*.

Fifthly, The velocity of the blood is in a general ratio with the amount or force of the irritability or muscular power of the part and its vessels ; and its rate, in the leading branches of arteries and veins, is according to the capacity of the intermediate capillaries, compared relatively with that of their own diameters :—provided the blood is neither much congested, nor stagnant in the reticular plexus ; for in that case, the velocity in the leading capillaries depends on the relative capacities of their arteries and veins.

Lastly. It appears from the amplified experiments and researches of the first physiologists, and from observations on the diseases and injuries of the body, that the destruction of the vital or muscular principle

of the heart and blood-vessels, by crushing either the brain or spinal marrow, or both, follows the same laws, as its destruction by lightning, blows on the stomach, or by concussion of the brain; while the removal slowly of either the brain or the spinal marrow, produces an effect on the action of the heart and of the blood-vessels, which is either not immediate, or is analogous to that, which ensues from injuries to the cerebral and spinal organs from disease or sharp instruments, producing great and deep lesion, but withal local:—shewing, that irritability or the vital principle is of the same character, nearly in animals as in vegetables; liable to be extinguished by general impressions, if sudden and powerful, but existing long under the most severe injuries in the most vital parts, if they are slowly inflicted, and of limited extent.

I have endeavoured to restrict this brief essay to the consideration of facts and experiments, and to deduce nothing from them, but what may legitimately be done, in addition to those inferences, which have already been drawn by others on the subject of capillary circulation; I shall, therefore, offer only one concluding conjecture, on this most fertile and subtle theme of animal life. May it not be compared to a unit of power, in any one fraction of time; ever dissipating and ever generating, and retained by intimate but delicately poised affinities to the physical stratum our bodies, and with a power proportionate to the slowness and gradual force of any divellent cause? The

physical frame, however, seems to part quickly with its vitality, when, as a unit of power, in a fraction of time, it is suddenly attacked: for the vital principle, that survives protracted injuries, would appear not to be the identical power, which first met the infliction of them; but is a power gradually generated, since that period, from the non-naturals of life, and which suffers expenditure, according to the force of retention, which the animal fibre possesses. And as to its *habitat*, I think I cannot better further define it, than in the language of Mr. Hunter, which many observations have tended powerfully to countenance. "This "living principle of the blood, which I have endea- "voured to show to be similar in its effects to the "living principle in the solids, owes its existence to the "same matter which belongs to the other, and is the "*materia vitæ diffusa*, of which every part of an "animal has its portion: it is, as it were, diffused "through the solids and fluids, making a necessary "constituent of them, and forming with them a per- "fect whole; giving to both the power of preserva- "tion, the susceptibility of impression; and, from "their construction, giving them consequent recipro- "cal action."

"The blood being evidently composed of the same "materials with the body, being endued with the "same living powers, but from its unsettled state, "having no communication with the brain, is one of "the strongest proofs of the *materia vitæ* making

" part of the composition of the body, independent of " the nerves; and is similar, in this respect, to those " inferior orders of animals that have no nerves; and " where every other principal of the animal is dif- " fused through the whole."

ESSAY III.

ON THE NATURE OF INFLAMMATION.

There are a few terms, in common use in medicine, which, from the undefined meaning attached to them, and their indiscriminate application, have led to much embarrassment and ambiguity in argument; and in practice, to a good deal of injurious generalization of treatment. Like the terms in metaphysics, they have brought medical men into argumentative array against each other, and have produced that diversity of opinions, on many subjects, which, perhaps, a more strict attention to the definition of the chief terms employed would have considerably diminished, if not altogether prevented. Of these, the term inflammation is not one of the least important, nor the least

common in its vague and indistinctive meaning and application to disease. The term itself is of so precise a nature, when applied literally to the physical condition of combustible matter; that, when it is employed as expressive of morbid action in the animal body, the young mind naturally transfers an easy credence to its being as strictly expressive of a specific condition in its figurative application; and often neglects to inquire strictly into the categories of the things related, by resigning this necessary exercise of the understanding, to the unquestioned adoption of a talismanic term.

There may be said to be two principal pre-requisites, which, to a complete and unfettered understanding on any case of supposed inflammation, require to be tacitly understood, if not expressively established, before a strict *ratio medendi* can be instituted between any two medical men. They are supposed, first, satisfactorily to define to each other, what they severally understand by the term, inflammation; and, having then agreed upon the pathological conditions of the part or vessels, they have next to ascertain, if the case before them be one of the same morbid categories with, or is analogous to, the definition, which they had previously acquiesced in, as constituting inflammation. Instead of this, how often do we see many men, of the first eminence in the profession, entertaining opinions considerably different, as to the condition of the vessels constituting such important and conspicuous phenome-

na, as those, which characterize inflammation; though it is consoling to think, that this difference of opinion does not produce that discrepancy of treatment, which, judging from the opposing *data*, on which they severally ground their indications, might have been expected to have taken place, The grosser phenomena of external inflammation are so obvious, that no difference could ever arise as to its existence; whatever may be the opinions, respecting the essential or efficient cause of the appearances, or however different may be the modes recommended to subdue them. But, even in external inflammations, considerable differences have prevailed, and still exist, respecting the actual nature of the phenomena: and the several modes of counteraction and cure, that have been employed, have not so entirely settled the argument, as to give a complete victory to any one opinion; for each party has respectively arrogated the remedial proof in favor of their individual creed. Supposed internal inflammation, however, presents the most fertile field for misconception, ambiguity, and difference of opinion, both as to the nature of the morbid lesion and its treatment. Setting aside all differences, that may obtain about the proximate condition of any degree of what is called inflammatory action, it is sufficient to advert, with what facility the term inflammation is applied to many internal disorders of the body; and, when it is once named, or mentally applied to the disorder in question, how tacitly and patiently we are apt, in our early

practice, to resign our remedial indications to this adopted term,—as if we had nothing to do with this internal fire, but to put it out as quickly as possible.

A figurative term of this arbitrary nature, when once adopted, or assented to, is not easily disenchanted of its influence. With many it is so associated with the lancet and other antiphlogistic means, that if the term inflammation is allowed to be so much as named, it is difficult to resist the necessity of the conclusion—that venesection or reduction must follow. The experience, however, of a moderate practice will shew, that the vessels of a part, or of an organ, may be in a state, to which no other common term, in medical language, can be so feasibly applied, as that of inflammation; and yet venesection might be injurious, and at all events not necessary.—Certain kinds and stages of erysipelas, ophthalmia, gout, rheumatism, and internal congestion, will afford many illustrations of this exception to conclusions following such indefinite premises.

It would have been more consistent with a philosophical pathology, to have had a term more strictly expressive of the actual, or generally allowed condition of the vessels affected with this preternatural commotion; for if the term was granted to have been correct, in any one class or instance, all contingent argument would become more logical and precise: but, if it was disputed, another term could be adopted for the same or other classes of instances, and the subject would have remained open for any chain of

reasoning or illustration. The term, as it now stands, embraces so wide a range of morbid actions, that in a therapeutic view, some of them stand as opposite to each other, as any two diseases on the nosological scale.

If, by inflammation is meant, that a part is affected with swelling, redness, and pain; it is easy to find all these existing in some complaints and constitutions, which require very different modes of treatment: and if *a posteriori* evidence be allowed to affect the truth of any proposition, it surely here ought to vary the denomination of the morbid condition. Again, if only one of the above phenomena be observed in any instance, yet a very violent and serious inflammation, notwithstanding, may exist, and require most active measures of counteraction. Any system of nosology will show, how intimately inflammation is connected with the essential character of diseases, arranged under very different classes; and if the student were to suffer his mind to be more exercised about the etymological classification of the disease, than with its constituent nature, as depending on the different degrees and states of inflammation, he would be perhaps adding an improper treatment to a mistaken and illusive pathology. Experience has served to correct not a few of the author's academical impressions in this respect, and observation has at times discovered them in others; as when nervous and spasmodic affections, commonly so called, have been afterwards assigned, in many

instances, to states of the blood-vessels bearing the chief characters of inflammation ; and as when apparent violent and inflammatory commotions have, through more acquaintance, been referred to their real sources—morbid and temporary excitements of the nervous system.

The term inflammation, then, had better been confined, as rather predicating, in a generic sense, the supposed preternatural condition of the vessels of a part implicated in disease, than as a denomination of the disease itself: and in this way nosologists have sometimes endeavoured to distribute it in their systems. Notwithstanding, how often is the term made use of to express the disorder itself. Thus in most of the acute or sub-acute complaints of the chest and abdomen, inflammation of some of the contained organs is immediately announced ; and even in the purest cases of idiopathic fever, the whole disturbance is readily attributed to inflammation of this, or of that viscus. No doubt, there may, in all these examples, be states of the blood-vessels as pregnant with danger, as if they were beset with inflammation, as commonly understood ; yet to act upon this idea, would often lead to improper measures of relief, and to disappointment in the result.

The literature of inflammation abounds with much ingenious theory, and has been illustrated by a multitude of instructive facts and observations: and it is no unedifying employment to collate the various opinions, that have been entertained on the subject, and to see

the very opposite conclusions, at which the various authors and reasoners have arrived. The volumes of medical record have diffused these several opinions so widely, that, independent of the more expedient dedication of leisure, I consider it quite supererogatory to enter upon any lengthened commentary, on what has been so often analyzed and digested; though occasional notes, made through a tolerable series of reading, would have made the task of minor difficulty to myself. Before, however, entering more fully on the subject, it is necessary to state, that of the several opinions, which have been promulgated as to the constituent nature, or what has been called, the proximate cause of inflammation, they have of late arranged themselves, and do so still, under two chief classes; —those, which attribute inflammation to an *increased action* or *energy* of the vessels of the part inflamed; —and those, which make *debility* or *deficient energy* of the same vessels the constituent of the disease.

From what has been shown in the preceding essay, it will be anticipated, under which of these general classes the author has disposed of his opinion on this subject; and, it perhaps argues no great gift in any thing allied to physiological induction, so to have voluntarily decided, considering the host of evidence now collected, and the recorded assent of some of the first medical men to their legitimate reception. I do not say, I shall illustrate professedly the truth or probability of this latter class of opinions; as this would be

to contend for opinion, and not to analyze a process of nature: but, as personal investigation may necessarily lead any one to the same result, to which others previously have arrived, it is but justiee to the prior discovery, to let posterior research give, however feeble, the support of its conviction. There are moreover some data, which observation has gleaned, and some conclusions, which have been adopted, that present some differenee from those, that have been, as far as is known to me, published; and which may serve, in some measure, to modify the theories of others, in this important and inexhaustible field of investigation. In all disquisitions on the nature of inflammation, there has been, perhaps, too much attention paid to the mechanieal and hydraulie properties of the blood-vessels implieated, to the neglect of the vital habitudes of the part. Distension and contraction being properties of inanimate matter, much of the inflamed condition of the vessels has been referred to these physical states, and the data made use of have been often formed from them, as the simple and effieient terms of the pathologieal equation. These phenomena, however, are not the first links in the morbid catenation, but only some of the early visible sequences of preternatural movement; it is then plain, as has been before and elsewhere notieed, that our elementary data must be plaeed still higher up the scale. That this can be done, without relinquishing the fair field of zoological analysis, has already been attempted to be

shewn, and we shall now resume the further application of the process.

A very appropriate preliminary to any view of the nature of inflammation, is the consideration of some phenomena of the human body, which cannot be called preternatural or diseased; though their extremes nearly approach to a very common precursor and attendant of disease,—namely, *irritation*. The chief of these are, *blushing*, *erubescence* from heat, cold, and from friction, and *florid tumescence* of the papillary tissues. At first view, it may be thought, that any strict rationale of these phenomena would serve very much to elucidate, if it did not carry with it a necessary explanation of the intimate nature of inflammation: yet, when it is recollected, that these are, in a manner, natural and healthy phenomena, subsiding quickly with the cause which excited them; they cannot strictly be held to have a close analogy, and far less an identity of nature, however different in degree, with affections painful to sensation, always injurious to health, and seldom or never subsiding simultaneously with the removal of the exciting cause. The experiments that have been noticed in the preceding essay, show, that the application of a very *slight* relative stimulus has the effect, on the capillary *plexus* of vessels, not of contracting their natural diameters, but of throwing them into a state of more *tensiveness* and *erectility*, than they previously exhibited; while the blood became somewhat increased in velocity, and

especially in the leading capillary branches; and this was the more evident, the more that the vessels were immediately previous in a small degree of *atonic collapse*. It has also been shown, that any portion of vessels, being in this *atonic collapse*, were liable to be easily distended beyond their natural dimensions, or what was neeessary to health, if the heart's action was a eonstant power, and more so, if it was excited. And, when it is remembered, that the *materia* or *vis vitæ** exists in all and in every part of the body, independently of the heart and of the nerves, but is liable to be excited, expended, and exhausted by stimuli and sedatives, conveyed through the nervous system, or applied direetly to the part; it may be seen, that all these several phenomena receive a eonsequential explanation. Beyond the habitudes of this *materia vitæ* we as yet cannot go, nor push farther any thing like analytical inquiry; for were a step legitimately obtained beyond this, as yet *ultima Thule* of physiology, we might then set many questions in medicine at rest, besides those

* By these terms, it is always meant to be understood what Dr. Philip ealls the museular power, as distinguished from the nervous system; and it is not pretended to decide, whether the term *vis* or *materia* is the more physiologieally eorrect. The essential nature of the living prineiple may be safely left to future diseovery, if it be within the grasp of human scienee; but we may as fairly argue on its properties and laws, as the chemists do on the subject of ealoric; though the most eminent of them are not agreed, whether it is a quality of matter, or a material substance.

which agitate the psychologists and phrenologists of the day.

Blushing is characteristic of man alone, and is always preceded by some moral emotion, and that emotion is either shame, or what affects modesty. Now these emotions are of the depressing kind, and produce a momentary sedative sensation, which acts on the nerves, and through them produces an atonic change in the capillary expansion. If the sensation be weak, and the heart not sharing in it, a sudden dilatation of the capillary tissue of the cheek takes place,—the heart being a constant propelling force, while the capillaries of the cheek yield and become distended. But if the sensation be deeper or more general, the heart feels it, and is momentarily bereft of a moiety of its muscular power; the cheek and surface of the body become then proportionably pale, to which, however, succeeds a deeper blush, and often a pretty general suffusion, from the greater previous capillary atony. It is to be also remarked, that the capillaries of the cheek have a peculiar vascularity of easy repletion; for these vessels, so alive to moral emotions, are the index of the nascent and the fading fires of a hectic fever.

Erubescence from heat arises from the stimulus of heat erecting the capillary tissue, as well as from the expansion which heat causes in the volume of the blood and of the part. Friction acts nearly in the same manner; but if it be continued too long, or be too severe, then we have an exhausted condition of

the local materia vitæ, producing effects quite of another nature. Cold acts reversely to heat, but sometimes the same apparent phenomena, from either cause, follow. In the first place, it abstracts, repels, or diminishes the materia vitæ of the cuticular capillaries; the consequence is, an atonic dilatation of the vessels, to a degree short, however, of any thing paralytic, and which a slight application of heat or friction quickly restores to ordinary contraction. Cold has often, in such cases, been considered a direct stimulus. I am Brownonian so far, as not to see, in this common and healthy phenomenon, anything like a stimulus. The appearances, which indicate the supposed effects of a stimulus, are first produced by the constriction of the whole surface of the body, thereby throwing the heart, in a healthy person, into a livelier action, whilst the capillary expansion of the skin next presents a less vital resistance to the impetus of the blood. When these reciprocities are in moderation, the circulation is like the flux and reflux of the tide, giving the whole vascular system a wholesome exercise, which soon subsides into the general equilibrium of health. But, if any of the fences of the shores of the current of the blood be defective, we may have, from a slight cold, a sequel of effects, of a permanently injurious, instead of a temporary and innocent or beneficial nature.

The *florid tumescence* of the papillæ and penis depends on a vital erectility and influx, and not on any

thing like a passive congestion. The stimulus, whether sensorial or extrinsic, throws the collapsed vessels into a state of tensiveness and elongation; the approaching blood, while it is thus solicited to the part from the topical increased capacity, also adds to the accumulating vital power, in proportion to the extent of the turgescence. The collapsed or atonic state of the vessels of these parts, is very identical with that condition of the capillaries, wherein the visible circulation has retired, and the vessels remain pale and quiescent, but which a slight stimulus soon renders florid, and more or less turgid.

All these preceding phenomena, however, lie within the reciprocal play of healthy movement and reaction; but we shall now proceed to enter on the threshold of disease, and on the consideration of phenomena strictly morbid.

Irritation, situated in any part of the body, when at all affecting the vascular system, bears such a similarity to the constituted and obvious phenomena of inflammation, that any tolerable solution of its nature will anticipate much, that may be said on the subject of the proximate cause of this latter affection. Vascular irritation, whether produced by a foreign body, or by the excitement of the secretions &c. of the body itself, is characterized by some uneasiness, and by a turgid state of the blood-vessels of the part; both of which do not subside immediately on the removal of the exciting cause. The part, then, has received an im-

pression, from which it does not quickly recover, nor resume the tonicity of healthy action. Or, in other words, the vital power of the part is relatively impaired, in consequence of that previous expenditure which all injuries and inflictions occasion; and its restoration can only be gradually restored by rest, and the constant suppeditation of the blood. When the exciting cause continues, the irritation is a constant phenomenon; and if it be moderate, it may not so far debilitate the vessels concerned, but that they may retain their nutritive powers in some proportion to their temporary enlargement; and so adventitious growths and accretions may be the result, especially if the fibrin be abundant in the blood, and no outlet in the seat of the irritation. But if the irritation be severe or long continued, the waste of the materia vitæ may be felt, not only in the constant debility of the part, but also from derivative supply, in the weakening of the whole constitution. In the above modes, large tumors of various kinds have arisen from irritated moles and warts, polypi in the nose from sternutatories; and pterygia and opacities in the eye from hairs &c. irritating the conjunctiva. Large tumors and accretions have also beset the stomach, duodenum, and liver, from the use of too stimulant food and drink; while a small ulcer has debilitated the constitution, and pain, that great spendthrift of the materia vitæ, has, without much perceptible morbidity, brought the sufferer to the grave.

Morbid irritation, then, may be said to consist, essentially, in a preternatural expenditure or diminution of the vital power or materia vitæ of the part affected, followed and accompanied generally by a dilated state of the blood-vessels, in consequence of a reduction of that power, which preserves them naturally in a medium state of tensiveness and contraction; and not, as has been supposed, in an increased action or phlogistic energy of the vessels affected.

The proper subject of this essay being now approached after these preliminary inquiries, a definition of what is generally meant by inflammation, or a summary of the phenomena, by which it is characterized, may be stated; as also an enumeration of the antecedent or exciting causes which are acknowledged to produce it. These last will, however, claim our first attention, with the view of considering them as they affect the animal body in general, as well as how they are the excitants of inflammation.

The chief of these causes are, heat, cold, external injuries, as wounds and blows, chemical and mechanical stimuli, poisons of all kinds, and the over excited use of any part or organ. Now, it is plain, that not one of these causes adds any essential power or physical bulk to the part, or to the body. They all either stimulate the materia vitæ to an undue expenditure, producing vital debility of the blood, membrane, and muscle; or else they directly induce a great waste of the same materia vitæ, in a very small comparative

section of time; or else, as in the case of severe cold, the materia vitæ is repelled or suspended in the part: but the ultimate effect in all, previous to the accession of inflammation, is a reduction more or less of the vital powers of the part or organ, to that extent, that with the removal of the exciting cause, the healthy state of the part is not spontaneously restored. This reduced or impaired state of the vital or muscular power of the part or organ, being considered as the essential constituent in the first links of the chain of sequences in inflammation, the posterior phenomena depend again on the nature of the part, and the kind and strength of the constitution at large. That such an impaired state of the materia vitæ necessarily takes place, before inflammation is fairly instituted, is legitimately inferred from the experiments and observations already cited. We have seen the first effect of a strong stimulus, to be contraction of the leading capillaries, to a very perceptible extent, which has been followed by that relaxation, consequent on vital expenditure, and which then simulated all the appearances of inflammation. We have also seen, that a wound or puncture was followed by these phenomena, in a more rapid and marked succession.

It is shewn, likewise, by Dr. Philip in his Exp. Inquiry, &c., Exp. 27th, that the application of sedatives, as tobacco, has a direct effect in reducing or impairing the vital or muscular power of the capillary circulation, which can again be restored to activity, by the application of stimuli, as alkohol: and, in other

experiments, blows, or concussions are noticed, as having produced the same atonic or sedative effect on the capillary movements. Perhaps, there is not a better nor a more manifest example of this reduction of the muscular vitality being a necessary preceding condition to the state of inflammation, than the common effects of the application of severe cold:—frost bites being incontestible illustrations of impaired or diminished vitality, in the first instance, and subsequently, of atonic distension of the vessels of the part. That mere stimulation is not a direct cause of inflammation may, besides, be negatively inferred; for the most violent exercise of the body and of some of its organs often takes place, and yet no inflammation follows. Internal stimuli are also very often swallowed, to the production of the highest vascular excitement; and, yet inflammation will not ensue—the natural powers and movements of the body returning with the withdrawing of the stimuli. Whenever inflammation does follow, in consequence of any of these excitements, it is found, on strict observation, that a period, more or less long, of atony or debility has intervened between the period of direct excitement, and the subsequent evolution of inflammation; and to this period, however short, must be ascribed the immediate or proximate movement of the first inflammatory phenomena.

As has been before remarked, it is not necessary, that this essential stage of atony should be produced

by excessive stimulation, for it may be directly induced by blows, concussions, sedative poisons, and cold; and there is just reason to ascribe many idiopathic inflammations to some cause acting in a similar manner—by abstracting or reducing, with more or less celerity, the materia vitæ of the affected part. Even in pneumonia itself, it will be found, that a period, presenting some indications of collapse or atony, in slight chills, horripilatio, uneasiness, and anxious respiration, has preceded that more obvious assemblage of symptoms, termed inflammation of the lungs.

When inflammation arises from mere plethora of the system, the relation of things does not require to be altered; for the part which becomes affected, is the part whose tension has not kept pace with that of the other parts of the system, or with the increasing momentum of the blood, and so becomes relatively debilitated. That such is a case, may be strictly inferred; for we have seen, that if any set of capillary vessels preserve their tone and tensiveness, the appearances of inflammation do not take place.

Without, at present, digressing farther into any illustrations of this primary link of the morbid sequences of inflammation; a few observations may be made on what is termed *re-action*—a term, which has, since the days of Hunter and Cullen, been in much vogue, as expressive of the full evolution of the specified disease, especially when it is accompanied

by a phlogosed state of the part or system. The term would seem to imply, that a positive or energetic action, of an independent origin, has commenced, in consequence of the impression made by some previous agent. Now, though the term has as good a practical meaning, as any other that might be used, yet it is presumed, it is far from giving a correct idea of the catenated condition of the disease. The phenomena, which are comprehended in the abstraction—re-action, do not arise, in local inflammation, from any superadded or acquired powers of an energetic nature, in the general circulation or in the vessels leading to the part; they are the direct result of the partial absence or diminution, relative or absolute, of a power, which formed the healthy constitutent of the part, and are not the reflective powers of a new agent making a positive impression. The power of the re-action has always been considered, as proportionate to the force or quantity of the previous offending agent, provided this does not totally extinguish the vitality of the part; but according to the experimental analysis, which we have noticed, it should rather be said, that the extent of the re-action, if the term be retained, is proportioned to the atony that has previously been induced, either by the direct abstraction, long repulsion, or by the exhausted stimulation of the vital power of the part affected.

Having said thus much, as endeavouring to show, that an atony or collapse of the capillary vessels, depending on an exhaustion or reduction of their materia

vitæ, is the precursory link in the chain of inflammation, and without which, whatever the exciting causes may be, inflammatory action does not take place, however violently phlogistic the consequent phenomena may appear; we shall now proceed to examine the constituted affection itself.

It would be a temptation to indulge too much in generalities, to make the embodied symptoms, called inflammation, the subject of undivided inquiry; it will be more consonant with the tenor of this essay, to make the phenomena, in succession, the respective subjects of a brief analysis.

Of these, the most conspicuous are, swelling, redness, heat, and pain.

Swelling.—When a part is affected with primary collapse, as from cold, concussion, or from some of the direct sedatives, the volume of the part is diminished previous to evolved inflammation; but when the atony is from excessive stimulation, no diminution, but a gradual enlargement, beyond the natural bulk of the part, takes place. When the tumescence has however obtained, it appears, from the before-mentioned experiments, that it is occasioned, in the first stages, by a dilatation of all the capillary vessels, but very principally of those of the veins. It is only in the advanced stages of dilatation and congestion, that the capillary arteries are equally distended: indeed, in all the tissues examined by experimenters, the veins form by far the greater part of the capillary system. The venous capil-

laries are of a more lax and delicate structure, and would seem to be less tenacious, or to possess less of the materia vitæ; consequently debility or the loss of tensiveness is first, and to the greatest extent, induced in them. How far there may be a considerable extent of vessels, carrying only colourless serum, which afterwards in inflammation admit the red blood, it is not easy to determine by observation; as in these apparent colourless vessels, the microscope often detected circulating red globules, but they travelled so quick and by single files, that their red colour only became observable, when they accumulated in a larger vessel, or were arrested in their progress.

The swelling is also proportioned to the laxity of the tissue, which is inflamed; in the more dense textures, as in the ligamentous expansions, periosteum, or sclerotic of the eye, the tumefaction is never considerable: while in the cellular texture, or in the less confined parts, it is often very great. This difference is no doubt owing to the more or less vascularity of the part, compared with its ambient support and confinement. Even in internal inflammations, there is good reason to suppose, that very considerable distension of vessels and tumefaction take place, especially in inflammation of the abdominal viscera.

The tumefaction of an inflamed part must likewise bear a very close proportion to the impaired tension of the vessels implicated, compared with the *vis a tergo*. In the incipient and distending period of in-

flammatory swelling, where there is much tone in the system, the vessels yield with a resistance, which is, however, still inferior to the momentum of distension: but if this momentum, at this period, or as long as the vessels preserve the power of vital contractility, be reduced in force and volume, the *renixus* of the vessels will be sufficient to restore them to their natural tension and diameters. Or if a stimulus, of a regulated power, be applied to the vessels themselves, or to the parts surrounding them; contraction or an inordinate exertion of their tensive powers, sufficient to overcome the distending force, may be induced, as we have seen in some of the experiments above related. As long as the vessels preserve this power of regaining their former diameters, on the reduction of the distending momentum, and exert a passive resistance to its force, so long they would seem to be in a state of active inflammation, and be capable of undergoing, what is the most desirable issue of this affection, namely resolution.

On the other hand, if the primary collapse or atony of the vessels has been more severe, and the distending momentum be, at least, not below the natural standard, the swelling may be more sudden and extensive, according to the nature of the tissues affected. In this case, the vessels yield with more celerity, from a greater deficiency of their tensiveness; and if no part of this power, but only their physical organization should remain, for to resist the momentum of the blood, then we may have hæmorrhage or gangrene.

The productions of serum, lymph, and purulent matter seem also to depend, in some degree, on the extent of the atonic distension of the vessels, as well as on the texture of the part; but this is a department of the subject, on which it is not now intended to enter.

Again, if the vessels have been kept in a state of diminished tensiveness for some time, without either the momentum of the blood being efficaciously reduced, or any of the ulterior issues of excessive inflammation having taken place; the vessels then lose their natural power of resistance and contractility, and become organically enlarged, from the deposition of lymph among their fibres and the surrounding tissues. The functions of these vessels may, however, regain some part of their integrity, or be capable of producing some vital though morbid secretions, as pus, coagulable lymph, and serum. In the ulcer detected in the frog's foot, Exp. 10, the ambient vessels were all enlarged and the part elevated, with the red globules circulating slowly round the margin of the ulcer; while the neighbouring circulation was in a quicker activity, though far less visible.

Swelling, then, is owing to vascular dilatation and to an increased quantity of blood, in the first stages of inflammation; and in the latter, to the additional effusion of serum and coagulable lymph into the cellular texture of the part.

Redness, depending entirely on the accumulated blood, requires scarcely any further observation; but

as the colour of active inflammation, or of it in its first stages, is always of a florid hue, it may be pertinent to reconcile this with the capillary veins, which form by far the greater part of the vessels inflamed. It has been seen, from the experiments referred to, that though the capillary veins seemed to be the first seat of dilatation, yet the blood, for some time, preserved in them its arterial hue, and even until complete atonic congestion took place, with paralysis of the vessels. It appears also, that the venous or modena hue is not cognizable in the natural circulation of the ramose capillary veins, or in the reticular plexus; it is only when the blood has formed an appreciable column in the larger capillary veins, that this colour is fairly observed. The celerity of the blood in the plexus also prevents any decided colour to be remarked in the healthy circulation. Another cause may be mentioned, as preserving the arterial hue in the inflamed dilated veins, which is, that as no secretion or only a diminished one, of either transpiration or accretion, takes place in this state of the vessels, so the blood does not undergo that change in the capillary system, which causes its floridity to be converted into the purple colour of the veins,—because this change is a process of health, and not of disease. The sub-livid colour of chronic inflammation is again owing to organically dilated capillaries, while the secerning actions of the part are in some degree restored, and so the supposed carbonised elements become in excess. It

appears from Hunter and some others, that the floridity of the blood depends on the strength of the animal, and on the vital tension of the red globules. From the experiments above cited, the commencement of inflammation was marked by a florid erythema, passing into a purplish, then into a livid hue, when the globules appeared to be much enlarged and relaxed in their orbits; and lastly, they lost their red colour altogether, and appeared to be dissolved into a brownish yellow serum, which was in time withdrawn or dissipated. It may also be observed, that the nearer the surface an inflammation is, the brightness of the red colour is the more intense; as in erysipelas and in inflammation of the conjunctiva: and it is supposed, that, in this last case, it is a good deal promoted by the oxygenous action of the air, or the decarbonization of the blood from the proximity of the atmosphere, similar to what is effected in the lungs; as the inflamed tissue in this species of ophthalmia, in a great measure, consists of veins, and yet we cannot distinguish them from the capillary arteries.

Heat.—The quantity of blood being increased in any part, while it continues in a state of circulation, will of itself increase the temperature of the part; and when it is considered that the transpiration and secretions of the part are, in inflammation, also arrested or greatly diminished, and that such secretions, when at work, carry off a great portion of caloric from the body; the combined result must be an augmentation of the

local temperature, both appreciable to sensation and to the thermometer. This accumulated heat is also a new generated cause of commotion, for it reacts, as a stimulus to the debilitated fibres, increases distension, and irritates the extremities of the nerves expanded on the part. If much previous atony or collapse has taken place, the succeeding heat will prove the greater stimulus; and its evolution will be as these previous states, and as the power of the general circulation, or the *vis a tergo*.

Lastly, *Pain* is referred to distension, which in inflammation affects so intimately the whole tissues of the part, that, from the dilated vessels stretching and compressing the ambient fibres, in consequence of the propulsion of the blood and the impaired tensiveness of the vessels, the *fibrillæ* of the nerves are morbidly distended, as well as irritated by the increased heat. Pressure in this case, or supporting the distended vessels sometimes gives relief, as may be ascertained in some whitloes and phlegmons. Pain is generally felt to be in some proportion to the extent of the distribution of the voluntary and sentient nerves on the part inflamed; for instance, where they are fewer, as in the cellular and adipose tissues, the pain is less in cases of inflammation, than in the muscular or ligamentous parts, where the nerves are more thickly distributed. But deep and extensive inflammation may obtain in the viscera supplied by the involuntary nerves, without much, and in some cases, without any pain being excited.

Another circumstance, which modifies pain much in parts not thickly beset with nerves, is the confinement or imprisonment of the inflamed part, as under a fascia, the articulating ligaments, and the periosteum. This counter-resistance, though it may prevent much distension, yet increases the pressure on the nervous expansion. Toothache itself is owing to pressure from the dilated state of the radical artery of the tooth. Cold, for example, having first produced an impaired tensiveness of the vessel, it yields to the natural *vis a tergo*, and so the nerve is compressed by the vessel's augmented diameter in the bony canal, which of itself admits of no distension. Fear, or the idea of extraction, acts on the motive power of the heart with a sedative effect; the *vis a tergo* is momentarily diminished, the pain is relieved, and extraction is sometimes postponed, until composure of mind, or the heat of the body renews the torment and vexation.

Pain is of several kinds, as well as different in degree; but the continued, and the throbbing or pulsatile, are the principal ones in inflammation. The continued and burning pain generally attends simple or erythematic inflammation; and the throbbing is very often premonitory of the suppurative species, and generally precedes the formation of purulent matter. This painful pulsation has been attributed, by Hunter and many others, to the excited contractions of the arteries leading to the inflamed part, and by Parry, to the local increased momentum of the blood, without

his allowing any contraction or dilatation whatever to the arteries of the part, or indeed to any part of the whole vascular system. Now, since we have endeavoured to show, that inflammation in any part is preceded by a vital atony or collapse of the capillaries, to which succeeds the stage of adynamic dilatation; it must follow, from the texture of the parts, that these atonic affections will extend around, to a more or less distance, with an intensity gradually diminishing from the spot, which is the deepest implicated; and as the vessels leading to the part are very direct lines of sympathetic extension, the inference is, that these vessels will experience a degree of this reduced tensiveness and of dilatation, at some distance from the focus of inflammation. The *vis a tergo* being at a natural force, the leading dilated arteries will receive an increased column of blood; and from their tension being reduced, the surrounding textures will feel, more sensibly and even painfully, each direct propulsion of the heart on the sanguineous column. In this manner, the artery may be supposed, by the patient, to beat quicker and more violently; though it is not easy to understand, how any medical observer could suppose, that it beats more frequent than the pulse in any other part of the body.

In periosteal whitloe, this painful throbbing is oftener acutely felt, and there is good reason to think, that the local irritation induces so much loss of the vital tensiveness in the leading artery, as to bring on pas-

sive dilatation, until the mere organic elasticity is the only power, which the vessel has to oppose to the propulsive *vis a tergo*.

Any intimate theory of inflammation must also regard the velocity of the blood, whether it circulates faster or slower, than in the natural state of the vessels. Hunter and Parry being at issue, as to the alternate contraction and diastole of the arteries, yet agree in attributing no diminished velocity to the blood in inflammation. In fact, the former supposes the velocity to be much increased, and the latter says, it is as great as in other vessels not inflamed;* while Dr. Thomson appears to think, from his experiments, that the blood may be either retarded or accelerated, according to the different kinds and degrees of inflammation; and Dr. Philip is of opinion, that it is always retarded in the capillary vessels, when they are inflamed.

From what has been shown in this and the former essay, it will be seen, that the comparative velocity of the blood, in any vessel or set of vessels, depends a good deal on the relative capacities of the associated and intervening vessels. When inflammation arises from stimuli, the first pathological effect is a slight contraction of the leading capillary arteries, with an increased tensiveness or erectility of the reticular capillaries, which is soon followed by a passive dilata-

* *Dr. Parry's Elements of Pathology*, Aphor. 194.

tion of the whole vessels. At this period, the velocity is increased in the larger vessels and diminished in the smaller, owing to the increased capacities of the latter class; and this period may continue for some time, if the stimulus be still offending, and the system plethoric and irritable. When the inflammation is, however, fairly constituted, if the above noticed experiments have any value, it must be concluded with Dr. Philip and some others, that the velocity of the blood is, *cæteris paribus*, always diminished. Indeed the idea of debilitated capillaries will not admit of an increased velocity; since it has been attempted to be proved, that the natural or quick circulation in these vessels, is entirely dependent on their healthy properties, which include their vital tension and medium contraction.

Chronic inflammation would seem to be accompanied, not so much by a slower velocity of the blood than is in the active species, as it depends more on the vessels having lost their vital renitency, and have become habitually distended, with some restoration of their functions. In the severe stages of active inflammation, when suppuration or gangrene is impending, the velocity is far more diminished; and in simple congestion, it is also more retarded, than in any case of chronic inflammation.

Active inflammation, from *whatever cause induced*, may then simply be defined, to be a *morbid* and *passive dilatation* of the *capillary vessels*, *yet in a state of renitency;* preceded and accompanied by an

atonic and impaired condition of their *muscular or tensive power.*

And Chronic inflammation, to be a *morbid* and *passively habitual dilatation of inelastic capillary vessels*, with some degrec of the above state of their *muscular or tensive power.**

That such are nearly the respective conditions of the vessels, may, besides the direct proof recorded, be corroborated by many synthetical observations. To such as have been brought forward by others, may be added the gradual solicitation of vitality to a frozen part, and the danger of bringing suddenly the tide of the circulation upon it, before it has acquired some degree of tonicity. To a contused or concussed part, how beneficially are stimulant lotions first applied to prevent inflammation. Even in constituted inflammation, the application of stimulants with cold is of the greatest benefit; the cold acting, by abstracting the distending heat, while the stimulants excite and preserve the vascular contraction. In the chronic species, this is better illustrated, as the distending force is somewhat diminished. The success, which attends the application of liq. plumbi. acet. and vin. opii. to certain inflammations of the conjunctiva, must be

* A more correct and full definition must include the local or general condition of the blood itself; for it is more than probable that it is simultaneously affected. The momentum of the blood should also be included:—the above definitions being restricted to the state of the vessels themselves.

wholly ascribed to their producing contraction, and restoring the natural tensiveness of the vessels. Blisters, also, in some stages of internal inflammation, seem to act solely by their exciting the nerves to produce contraction in the contiguous inflamed capillaries; as the discharge which they produce is, generally, no ways commensurate to the benefit which they afford; and they never can be said to act sedatively on the immediate texture. I have also seen painful and inflamed ulcers treated successfully with tight plasters and bandages,—the vascular condensation soon leading to a cure. The recent practice of applying sulph. cupri. and arg. nit. in substance, to the eyes, in the early and active stages of inflammation, is still more corroborative of the principle of local vascular atony, being the essential and primary condition of the part inflamed. The beneficial action of ol. terebinth. in some inflammations, the piper cubeb. in gonorrhœa, and of gargles of capsicum in some species of cynanche, are all, it is presumed, illustrative of the same fact in pathology.

In fact, there are few cases of inflammation in any organ or tissue, but what the operation of remedies, of the most reputed application, will show that their physiological action partakes more of the nature of a stimulant to the corpuscular fibre, than of that of a sedative or an antiphlogistic. When the nature of the preternatural derangement is strictly considered, it is found, that the obvious phenomena of inflammation,

is not a simple independent process, but are the result of unequal quantities and forces acting upon each other, and producing a value, according to the respective powers that have been at work: and it is only when one or the other power is indicated by the result to have been in excess, or in a *minus* quantity, that renders any therapeutic indication appropriate or injurious. Thus venesection and stimulants, in the same disease, are often used, and fulfil the best hopes of cure. Though debility be considered the inceptive or generative condition in the process of inflammation, and it is not easy to be convinced, that dilatation of the vessels with diminished velocity of blood, is an essential associate of preternatural tone and activity in the same vessels; yet it is quite illogical and unpathological to infer, that this asthenic or debilitated state is necessarily to be treated directly by tonics and stimulants. It would be just as proper treatment of a drunken man, to pour more wine into his stomach, from the false idea, that he would thus regain the use of his tongue and limbs; because, forsooth, they are weak, and therefore he needs restoratives. The danger of giving a stimulant in active inflammation arises, not so much, from its being altogether inapplicable to the insulated condition of the blood-vessels; but, because it would injuriously increase the *vis a tergo*, and excite the distended vessels to a contraction, which they could not, at this stage, accomplish.

It would, therefore, still more weaken their fibres, by the ineffectual and hurtful expenditure of that materia vitæ, by which alone the vessels are to be restored to their healthy tension, when the contained column of blood—the distending force, is reduced in power or in volume. An antiphlogistic remedy is also supposed to be beneficial in active inflammation, not from its reducing the excess of vital action or power in the inflamed vessels, but from its unloading the weight from their oppressed fibres, and diminishing the momentum of the propulsive force to that degree, which may enable the vessels to recover their native tension, if active inflammation has been the case; or to moderate the power or quantity of the *vis a tergo* in the chronic species, so that the dilated, but not the paralyzed vessels may be left prepared for the judicious application of stimuli and alteratives.

In acute pneumonia occurring in stout subjects, nothing more, at many times, is requisite to subdue the inflammation, but to reduce, by powerful venesection, the *vis a tergo* and the volume of pressure; which if quickly done, the vessels will, in a very short time, recover their natural diameters and tension, and the functions of the lungs will be soon restored without any other medicinal aid, or through the process of any expectoration whatever; as the author has witnessed in many cases in the fleet. But, if this inflammation takes place in cahectic or in delicate constitutions, or if it supervenes on other diseases, the speedy or full

reduction of the momentum of the *vis a tergo* will not so readily be followed by convalescence; for we have in these cases two indications to follow, and we have but fulfilled one of them, in letting blood. The vital condition of the vessels implicated is superadded for our curative consideration. They perhaps will not contract with healthy tensiveness on the reduced volume of the blood; or else their energy is so far impaired, that general venesection does not unload the congested capillaries. In this case, stimuli, as blisters, and a regulated order of what are called pectoral medicines must be instituted; for the purpose of promoting secretion, and exciting capillary tone and action. This unequal balance between the tensiveness of the capillary vessels, and the propulsive power and volume of the circulation *a tergo* in the leading vessels, may easily elucidate the nature of many vascular commotions, which may be short of inflammation, or partake but little of its general character. Indeed, the ingenious Dr. Parry placed, as he says, but little importance to the term inflammation; as he supposed many serious derangements may take place, short of constituted inflammation, from what he termed an undue momentum of the blood,—which, according to him, is composed of its volume added to its velocity. With great deference to this respected pathologist, it is to be regretted, that he has almost left the proximate nature of this momentum unexplained. For as he denied all contraction and dilatation of a propulsory

nature to the arteries, with little mention of capillary independent circulation; and as he could not possibly attribute any selecting power to the heart—his chief moving power of the whole circulation, we are left in much doubt, in what manner or from what cause, this local momentum in any case originated. If the materia vitæ of any part or tissue is however brought in, as a term of the problem, and that it is essentially affected in every diseased action, pertaining to inflammation, there cannot be a doubt; the supposed defect in his pathological chain may, in some measure, be supplied: though the character of his momentum would require to be also changed from that of a positive agent, as constituted by him, to that of a passive result of unbalanced circulation.

In Aphor. 145. he, however, would seem to countenance the theory of two reciprocal agents in the production of vascular disorder, by saying, that "preternatural distension of vessels containing blood, "may arise from excessive general momentum on "the part of the blood, and of diminished resistance "in the vessels themselves." Notwithstanding, that the relative degrees of these physiological conditions to one another are susceptible of great modification and unlimited variety, and are sufficient, perhaps, to explain all the phenomena of vascular diseases not organic, whether sthenic or asthenic: he appears throughout his work, to attribute the most of diseased phenomena to simple increased momenta:—perhaps not being

willing to incommode the beautiful simplicity of his hydraulic system, by the acknowledgment of any other agent however much, though not so obviously, influential. In Aphor. 172, he seems careless of ascertaining, whether this local state of the blood-vessels arises from debility or strength, from diminished or increased action; the supposed fact of increased momentum appearing to him, to be a stage in the analysis of disease, beyond which it was neither necessary nor instructive to proceed.

Allowing, as has been before said, an atonic, or an impaired condition of the materia vitæ of the vessels, either relative or absolute, to be the necessary prerequisite of every degree and mode of inflammation, or of preternatural vascularity, the rationale of Dr. Parry's momentum, in almost every case as applied by him, receives, it is presumed, a more intelligible exposition; even if the fact of that necessary atonic state of the local vitality be as questioned by some, as it appears pathologically true to the author.

Dr. Parry, among several instances, attributes (Aphor. 484) idiopathic dyspepsia to morbid fulness of the vessels of the villous coat of the stomach; and that increased sensibility, acidity, and heartburn all originate from this vascular fulness. Now, it must be granted, that this is a valuable pathological observation; and in my late experience, no practice has generally succeeded better, where no organic disease was present, than the local abstraction of blood, with the use of

tonics and aperients in dyspeptic complaints, even occuring in weak subjects. The patients most subject to this disease are they, who are either of a delicate constitution naturally, or who have over-stimulated their stomachs in previous life; or they are those, who live in confined situations, or on improper food. General or topical debility is here induced from inordinate distension, or from frequent atony and stimulation of the vessels ramified over the circuit of the stomach; the consequence of which is, a tendency to a habitual dilatation of the capillary vessels, especially of the veins from their defect of valves, which dilatation occasionally leads to spasm and temporary congestions; and all this may frequently take place, short of what is called inflammation.*

* How much habits and modes of living have the effect of generating a relative constitutional debility in one class of organs more than in another, may be exemplified from such observations as these. From nosographical registers lately kept by me, and which have annually averaged from 1400 to upwards of 1800 cases of the complaints and diseases, naturally occurring in a large manufacturing town; one-fifth of these cases are affections of the cœliac organs, simulating all the forms of dyspepsia and bilious diseases. This proportion does not include the pure cases of abdominal inflammations, nor of cholera, diarrhœa, or marked hepatitis; and it seems to arise, among the working classes, from the early and repeated use of too stimulating food and drink, alternated, according to the state of trade and employment, with restrictions in diet and mental depression and excitation. On the other hand, I have found, that such complaints of the cœliac organs bear no such comparative large minority, among a strictly agricultural community, nor among large bodies of seamen.

Let the stomach and its vessels, however, be more suddenly deprived of a portion of their natural materia vitæ, by acrid ingesta, cold, or violent stimuli; we may then have great irritability of the organ, heat, pain, thirst, and fever; in fact, inflammation in some of its textures. Let the debility be still more quickly induced, which appears to be effected at times, by some endemic changes of the atmosphere; deep and wide congestion, similar to that which the capillaries suddenly suffer from the application of the solution of salt, may affect cholera; or even the gastric fever of warm countries, if the system at large has partaken also of the endemic atony, and sufficient power be yet left to the heart, for to react on the organ affected. It is the quickness and extent, with which a part or organ is bereft of the powers of life, compared with the natural strength and fulness of the heart and the rest of the system, which render the integrity of that organ or part precarious; and according as these respective conditions are increased, so will be the extent and danger of the subsequent inflammation. Any part impaired in its vital quantum of life, cannot essentially be replenished, by stimuli applied to the remainder, as these will the more exhaust its previous debility; the supply is only gradually to be restored by the blood going to the part, by rest, and free air. To stimulate, therefore, is not always renovate; the matter of muscular life must be conveyed through a sensible and appreciable medium;

and until this is effected, the part remains in a precarious negative condition, if it be not labouring under the direct effects of relatively impaired vitality.

Without, at present, endeavouring to extend any illustrations, of which this view of inflammatory action is susceptible; it may be requisite to acknowledge, what must all along be observed, that the views here given have not the claim of novelty; but substantially embrace nothing more, than what might have been inferred from the retailed theories of Vacca, Lubbock, and Allen, and which have been since more fully elucidated by Dr. Philip.

But, considering even the feasibility and superior logical accuracy, which this theory of debility alone affords in explaining inflammatory action, in the absence of all facts to support it; and seeing how limited the reception, which it yet has among medical men, if to what some assert, be added the language of others; it is surely no trifling compensation for the want of the credit of novelty, which is many times an object of questionable ambition, to entertain the hope of illustrating, in any additional degree, however small, the principles of such a theory:—especially, when personal observation and some studied experience have long brought repeated conviction of its accordance with nature, in opposition to the prejudices and respected canons of medical initiation.

Having said thus much on the subscription to the general theory of debility of the capillary vessels

being the proximate nature of inflammation; I wish to show, that Dr. Philip's further definition of inflammation contains a condition not provided for in the view, which has been taken in this essay; and which, on his own pathological principles, is not necessary to form an essential constituent of this affection. He says, "In short, inflammation seems to consist "in the debility of the capillaries, followed by an "increased action of the larger arteries; and is ter- "minated by resolution, when the capillaries are so "far excited, and the larger arteries so far weakened, "by the preternatural action of the latter, that the "power of the capillaries is again in due proportion "to the *vis a tergo*."*

The first condition of this definition being granted; the next, the "increased action of the larger arteries" is certainly a matter, neither of such easy proof, nor of such precise induction, as, at first view, might be imagined. That the larger arteries, in the ordinary circulation, contract and dilate in an active manner, alternately with the heart, and so propel the blood forwards into the respective vessels, is extremely doubtful.† And if the experiments of Parry and

* *Experimental Inquiry*, p 283. 2nd Edition.

† "Although the arguments, which I have advanced, appear "to me sufficient to prove, that, in the ordinary state of the "circulation, the muscular powers of the arteries have very "little effect in propelling the blood, yet I neither expect nor

the observations of some other physiologists have any weight; or if the effect of such increased action be strictly considered, it is beyond a doubt, that the arteries are endued with no other capabilities of motion, but those of momentarily yielding very slightly to the pulsatory column of blood,* of recovering their medium muscular tensiveness and diameter, during the diastole of the ventricles, and of accommodating their diametrical capacities to the varying volume and momentum of the blood. But these properties are quite different from those, which make the period of distension that of relaxation and quiescence, and that of the recovery of the medium length and area, the state of active contraction. That an artery contracts on the application of a stimulus, or when irritated, is a fact, that may be at any time ascertained; but this contraction is not of an alternating nature; it is permanent, like the contraction of any other irritated fibre, as long as the irritant is present, and the *vis vitæ* or the power of contractility remains.

" desire that the prevailing opinion should at once be universally " abandoned."—*Medical Literat. 2nd Ed.* p. 361.

* That this momentary or pulsatory distension takes place, both in the line of an artery's transverse and linear axis, there can be little doubt, as it may be observed in very superficial arteries; and I can daily observe a degree of it in the course of the superficial volar branch of a radial artery, which last, undivided, continues to run directly under the skin, instead of under the muscles of the thumb.

However acute Dr. Parry was in his experiments, yet it is presumed, as has been above remarked, that the irritation of the wound and of the air on the arteries of the animals, on which he experimented, kept the vessels in this state of uninterrupted contraction, while under admeasurement and inspection ; and that it is probable, when the animal recovered from the experiment, that the artery would again be found to extend its area and length sensibly to the propulsive impetus of the heart.

The active pulsatory contraction being then denied to the larger arteries, in the healthy state of the circulation ; it follows, as a mere matter of conclusive argument, that such an action cannot be increased during disease. Not the rest the negation of it on a *sequitur* of this kind ; it may be still further rendered unequivocal, from what has been already advanced, as to the impaired vitality of any tissue or class of vessels, as well as from adverting to what would be the effect of increased action in an artery—namely, contraction of its length and area, and not dilatation, which last is acknowledged by all to take place. The effect of a stimulus being to contract the area of an artery, in some permament, and not in a pulsatory manner ; and when the effect of the stimulus subsides, passive dilatation is found to follow, in a ratio to the irritability or materia vitæ expended in effecting the preternatural and previous contraction. The artery, in this latter state, is now yielding to the

constant propulsion of the *vis a tergo*, and the force and extent of its pulsations will be proportioned to the extent of dilatation, and to the power of the *vis a tergo*. When an artery is in this excited condition, the velocity of the blood early inflammation, as has been observed, may be increased through its canal, owing to the enlarged capacities of the succeeding capillaries; and its stronger pulsations afterwards arise from the momentum of the blood being increased, and the sides of the vessels presenting a subdued resistance to the systolic force of the heart.

This I venture to consider to be the nature of the supposed "increased action," and not a primordial or independent activity in the artery itself. If this last were the nature of the vessels, it is not easy to see, as has been urged by some others, how depletion would reduce this action, as the artery, in this case, would have only more room to act with its preternatural activity; but in the view of passive dilatation from a compressing fluid, the reduction of the pressure must consequently be followed by a more or less recovery of tone and tension, provided the exhaustion of the vascular fibres have not proceeded beyond a certain extent.

Instances of this supposed increased action are often cited, as taking place in the carotid arteries, and producing undue determination of blood to the head; and the throbbing felt is considered a very presumptive proof of this increased action. These irregular

affluxes of blood, without general fever, generally take place in the nervous and delicate, and in those, whose brains are much exercised by study, and mental exertions. They often arise from cold, or are associated with some derangement in the chylopoetic organs:—the result of all which causes is, to produce an impaired state of cerebral tone and tension; the further consequence of which is, an asthenic state of the blood vessels of the head, which by textural sympathy is propagated along the larger trunks. This impaired state of vascular vitality is attended by a slower circulation in the capillaries, and most probably, first or solely in those of the veins, which state alters the relative velocities of the blood, and so to dilated vessels is added an increased momentum in the larger arteries. The carotid arteries having then lost more or less of their tension, they yield, with a painful sensation often to the patient, to the direct propulsion of the heart on the proximate end of the sanguineous column; and it depends on the plethoric state of the whole vascular system, whether the carotids will then feel hard and tense, or soft and rebounding.*

* "What we call increased determinations of blood to particular "parts, are in general merely obstructions in the smaller vessels, "by reason of which, the blood cannot be so readily returned "through the veins; so that the current of blood transmitted by "the heart through the larger arteries, continues to accumulate

As a synthetical corroboration, that such a state of the vessels depends not on an inherent vital activity; purging will often not relieve the head-ach or throbbing, nay it will sometimes increase it; and if the general vascular fulness has been previously reduced, depletion will even be injurious. Correction of the chylopoetic disorder, with blisters and tonics, will in these cases prove far more serviceable; and many are relieved by wine and bark alone, when given in the absence of all pyrexia and plethora.

Dr. Philip, in the latter terms of his definition, supposes the resolution of inflammation to be effected, or the tone of the capillaries to be restored, by the preternatural action of the larger arteries. With due respect to the conclusions of this physiologist, it is presumed, that such physiological causation is liable to some objection, even on his own general views of the nature of the muscular power. Allowing that this supposed preternatural action exists, which has not been granted, still it is not an easy physiological process to understand, how tone is to be restored and debility removed from one part of a vessel, by the continued preternatural action of another portion of the same tube: the contrary would seem *a priori* to be the case. It is more consonant to observation, that

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"in those arteries, which accordingly become more distended "than others, but the action of which is never more frequent." —*Dr. Armstrong on Typhus Fever, 2d Ed.* 1818, *p.* 288.

in the spontaneous resolution of any notable inflammation, a partial effusion of serum takes place into the cellular tissue of the part; by which means the distension of the capillaries is relieved in a proportionate manner, and the restoration of their tone and natural tension is further accomplished by the slow renewal of their materia vitæ from the blood; provided the exciting cause of the inflammation has been removed, or has ceased to act.

All the theories on the proximate causes of inflammation, which I have examined, make the increased action of all or of some sections of the vessels an essential condition in the morbid catenation, while dilatation of the vessels is allowed by all to take place. If it were proved, or if it stood within the verge of strict induction, that the action of either the leading or capillary arteries is preternaturally excited in inflammation; it would remove all inducement to attempt, even by experiment, to substitute a simpler agent or *modus agendi* for the agencies of two states—namely, debility and hypertonicity in the same part or process, which are liable, in ratiocinating on their relative and reciprocal actions, to come into confliction. But if a relative or an absolute asthenic state be considered the general prerequisite of all the phenomena, and from what has been shwon, the existence of such a state is more than hypothetical, even if the proof be thought deficient by some; the

rationalia of the phenomena of inflammation, and of all, or of most irregular affluxes of blood are rendered less embarrassed and involved.

If a fact, however, be forced on our observation, in the pursuit of any science, former modes of thinking have prepared a sceptical defence against the reception of any correlative doctrines. An overweening desire for generalization will again be apt to seduce us, when we have fully subscribed to the fact, to wrest the former phenomena, which we witnessed, to the Procustean idol of our minds; imagining sometimes that any illustration, however remote, will add stability to our new principle, the truth of which we are so zealous to establish; and except its application will explain all things, however mysterious and recondite, we are prone to hold it light in value, and may overlook the real utility of its limited application. I shall therefore forbear, in this essay, to attempt any further illustration of the principle alluded to, as applied to the rise, progress, and decline of many other diseases, besides those already mentioned; or to notice the practical circumspection and utility, which this principle enjoins and enhances in the treatment of all their stages; and shall briefly advert to those conditions in the proximate nature of inflammation, which have been mentioned by some others of our chief pathologists, and which are either analogous to, or stand in the logical place of the asthenia, or the impaired muscular power noticed in this essay.

Dr. Cullen, in Par. 239 of his First Lines, sets out with the position, that there is an increased impetus of the blood in the vessels affected with inflammation, and that this impetus is owing to the increased action of the vessels of the part itself. After endeavouring to refute the opinion, that this increased action was occasioned by lentor or viscidity of the blood, or even by what was called an *error loci*, by arguments, which he confesses are not absolutely conclusive, he betakes himself to his favorite occult *vis medicatrix naturæ*, and assigns spasm to be the proximate cause of inflammation. Even inflammation arising from direct stimuli, as well as that spontaneously affecting a part, is supposed by him to have a spasmodic stricture of the extreme vessels, as the efficient cause of all the phenomena of the supposed increased action, and of all its subsequent affections. He, moreover in Par. 244, says that inflammation may be occasioned by some causes producing an inequality in the distribution of the blood, which may be thrown in unusual quantities on some particular vessels, to which it must necessarily prove a stimulus. In this proposition he comes nearer to the late views of Dr. Parry; but the causes occasioning this unequal distribution of the blood in either view, is the desired object of pathological research.

From what has been already predicated of that state of the capillary system, called the atonic collapse of empty or uncirculating vessels, and which

has been shown to be connected with an impaired or suspended vitality of the fibres of the part; it will be seen what contemporary analogy it has to the spasm of our author. The alleged constrictive state of the fibre, which was supposed to constitute spasm, has been considered the enervated state of the capillary vessels, which passively yielded to the *vis a tergo*, as the obvious symptoms of inflammation appeared; instead of acquiring that active tension and erectility, which form the condition of healthy circulation. The supposed continuance of the spasm is occasioned by the congestive state of the blood in the renitent capillaries, before either the effusion of serum in the ambient tissue, or the formation of pus takes place; and so, what was reckoned a stricture in the extreme vessels is here interpreted to be an unsecreting distension of the capillary plexus—the one the effect of *hypertonicity* in the vascular fibre itself,—the other of either direct or indirect debility.

The ideas of Brown on the subject of inflammation are, like many applications of his general doctrine to the intimate phenomena of physiology and disease, extremely vague and unsatisfactory. The wide embrace of his theory made no difficulty in attributing his sthenic, or what is commonly called active inflammation, to an undue quantity of blood stimulating the vessels by distension; which distension was the cause of the reaction, viz. more forcible and frequent contractions, the violence of which occasioned the

pain.* An accelerated movement of the blood through the extreme vessels, was supposed by him, to take place in active inflammation. Passive inflammation, according to him, was also occasioned by abundance of blood, but accompanied by a greater laxity or atony of the fibres of the extreme vessels.†

Though he also states how inflammation may arise from external injuries, and from what are termed the exciting causes; he no where advances to a closer analysis of the early sequences, than by saying, that inflammation may arise from a general diathesis, more particularly exhibiting itself in some one part or organ, without his condescending to theorize on the early corpuscular pathology of the part so affected.

Dr. Darwin, among many refined and most ingenious opinions on the processes of health and disease, entertained rather a singular idea about the essential nature of inflammation; for he says, "Inflammation "is uniformly attended with the production or secre- "tion of new fibres, constituting new vessels; this "therefore may be esteemed its essential character, "or the criterion of its existence. The extension of "the old vessels seems rather a consequence than a "cause of the germination, or pullulation, of these "new ones; for the old vessels may be enlarged, "and excited with unusual energy, without any pro-

* *Works of Dr. John Brown*, London, 1804; vol. 2, Par. 207.

† *Idem*, Par. 208.

"duction of new ones, as in the blush of shame or "of anger."* And as to the heat and pain in local inflammation, he adds, "Great heat is produced from "the new chemical combinations arising in the secre- "tion of new fibres, and great pain from the distension "of old ones, or from their increased action."† As to the generative cause of the whole phenomena, the author is no where so explicit or analytical, as he is on the subject of febrile movement; but it may be inferred from his general pathological views, that he considered the "sensorial power of irritation" to be increased in an inflamed part; and that it was not diminished nor repelled in the primary collapse, but became accumulated, until it preternaturally exhibited itself in the period of reaction.

Not to enter on the ample and highly practical disquisition of Hunter on the subject of inflammation, as his theory is so generally known, and has been so widely embraced by the profession since his time; I shall merely remark, that he places the very first act of inflammation in an increased action of the smaller vessels, gradually extending itself to the larger arteries.‡ He also allows the larger arteries to be always dilated in inflammation, though their increased

* *Zoonomia*, &c. by Erasmus Darwin, M. D. F. R. S. London, 3d Edition, vol. iii. p. 305.

† Idem, p. 307.

‡ *Hunter on the Blood, Inflammation, &c.* London, 1812, vol. 2, pp. 3 and 4.

action does take place; and, according to him, the velocity of the blood is always above what is natural. In a note, he also says, "But I have shewn that their "(the arteries) elastic power dilated them; and I "have reason to believe their muscular power has a "similar effect." The inquirer has perhaps to regret, that his ideas are not oftener rendered more explicit, as his language sometimes makes them difficult to be satisfactorily understood. As to the nature of the vitality of an inflamed part, his opinions are sufficiently precise; for, in speaking of the sensations of the part, he says, "The motions of the nerves have "nothing to do with the economy of the part, they are "only the messengers of intelligence and orders. It "appears that only the actions of the materiæ vitæ "in the inflamed parts is increased, and this increase "of action in the inflamed part is continued along the "nerve which is not inflamed to the mind,"*—a conclusion, as relates to the materia vitæ, differing greatly from that of the advocates of primary debility in the part, and is quite at issue with the doctrines, which, in this essay, I have, from analytic observation, been compelled to adopt. This idea of increased action created some difficulty even in the mind of Hunter, who again says, "The vessels, both arteries and veins, in the "inflamed parts are enlarged, and the part becomes "visibly more vascular, from which we would sus-

* *Hunter*, ut supra, vol. 2, p. 21.

"pect, that instead of an increased contraction, there "was rather what would appear an increased relaxa- "tion of their muscular powers, being, as we might "suppose, left to elasticity entirely. This would be "reducing them to a state of paralysis simply:"—"but "we must suppose it something more than simply a "common relaxation; we must suppose it an action "in the parts to produce an increase of size to answer "particular purposes; and this I call the *action of di-* "*latation*,"—"and I may also observe, that we have "an increased pain in the inflamed part in the diastole "of the artery, and a part inflamed being gently "pressed is made easier. These are strong proofs "that it is not a contractile action of the vascular coat "of the vessel; for in such a sensible state of vessels, "if they contracted by their muscular power, the pain "would be in their systole;"—"I should therefore "say, that in inflammation, the muscular coats of the "arteries do not contract."* Such were some of the difficulties which this great man had to contend with, in explaining the nature of inflammation on the theory of increased action in the vessels, which he even supposed to act and enlarge, "as we see the uterus increase in the period of gestation." Without more than alluding to this last process being an operation of health, and not of disease, as inflammation is; it is with deference proposed, whether the above patholo-

* *Hunter on the Blood, &c.* ut supra, p. 10.

gical data and observations do not give greater countenance to the principle of passive resistance being the preternatural condition of the vessels, than any thing partaking of an increased energy or action. Whether the hypersthenic or negative condition of the materia vitæ be the real generative cause of inflammation, must be allowed to be a most important problem in human pathology; but whether the one theory or the other will be generally embraced by medical men, will depend a good deal on the degree of inquisitive study, with which the more intimate processes of nature are examined; and on the deference which may be paid to the opinions and researches of those, who have taken, or may obtain the classical lead in pathology.

In the Croonian Lecture by Dr. Young, "On the "Functions of the Heart and Arteries," which is inserted in his "Medical Literature," 2d Ed., the causes of inflammation are placed in various relative affections of the capillary and large vessels, among which, constrictions, obstructions, and dilatations of the capillaries are reckoned the principal. These data having been premised, the deductions as to the force, quantity, and velocity of the blood, and the nature of the resistances, are very corroborative of the opinion of the passive state of the vessels in inflammation. That impalpable associate of organization—the materia vitæ, he does not reason upon, as it is affected in inflammation; though he seems to consider, that inflammation

is rather connected with diminished vitality in the part, than with its increase or preternatural activity: as for instance—"The immediate effect, "either of cold or of heat, may also sometimes pro- "duce such a degree of debility in any part, as may "lay the foundation of a subsequent inflammation." It has been endeavoured to be shown, how the relative degree of this debility, under other circumstances, is so very intimately connected with the *prima mobilia* of inflammation, in every previous condition of the part and general diathesis.

In Dr. Armstrong's valuable treatise on Typhus Fever, &c. 2d Ed. 1818, there are many pathological observations on venous congestion, as preceding excited inflammation, that, in my humble opinion, strongly corroborate the conclusions above inferred, as to the impaired vitality or tension of a series or mass of vessels, being the morbid prerequisite of inflammation. These congestions preceding obvious excitement, and of quick invasion, are greatly owing in the cavities of the body, to the distensible and lax nature of the vessels and that of the tissues in which these vessels are imbedded; assisted by the want of valves in the veins, and in the abdomen, by the want of the immediate effect of the supposed dilative attraction of the heart, from the interposition of the liver. Though the above-mentioned author does not carry his analysis far into the arcana of life, as the treatise is more strictly practical, nor particularly ad-

verts to the relative conditions of the materia vitæ, or the vital principle; he, however, involves the contingent nature of it, when he says in a note to page 21, "It is probable, that there is a greater loss of "balance between the arteries and the veins, in in- "flammation, than in simple excitement of the circu- "lation;" and again in page 165, "In truth the "venous congestions, which take place in the first or "cold stage of these examples (simple inflammation "of the viscera) appear to be the cause of the general "excitement which follows, and that excitement again "produces in some parts, a marked arterial disturb- "ance, which we denominate inflammation, and the "seat of which is, in all probability, determined by "some weakness latent in the organ affected, previ- "ously to the occurrence of the cold stage." In this enumeration of sequences, we are led to the first recognized link in the chain of inflammation—*weakness latent in the organ affected:* which weakness being increased by any of the occasional causes, such as cold, the feeble tension of the vessels immediately gives way. Dilatation then follows, and according to the degree and the quickness of this asthenic condition, so will congestion take place, to become in its turn an exciting cause of what is termed reaction, or the propagation of a degree of the same asthenic state to the leading arteries, if not to the heart itself.

In the "Study of Medicine," the generative causes of inflammation are treated in a comparatively sum-

mary manner, considering the copious and erudite disquisitions on other departments of pathology; and the little that is given is nearly a transcript of the doctrine on this subject from "The Treatise on the blood, &c." Dr. Good perhaps thought, that any other theory but that of Mr. Hunter was yet too limited and unsupported, to claim a place in a work designed to be a medical classic. As far as regards the doctrine of predisposing debility, he however says, "That inflammation more frequently takes place in atonic than in entonic habits;" and again, "That a susceptibility "of irritation seems to be a necessary adjunct in the "production of inflammation; and hence the real "inflammatory or phlogistic diathesis, is perhaps to "be found in increased irritability of the living fibre, "rather than in an increased rigidity and rigour."*

The doctrine of capillary debility and of the connection of inflammation with what has been called the nervous condition of the part, has also been noticed and advocated by a few other authors,† besides those mentioned; while the subject has met with much analytic investigation, from time to time, in the Medico-Chir. Review. Without directly espousing the asthenic side of the question, the Reviewer seems to attribute a good deal of early inflammatory action

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* *Study of Medicine, vol* 3, *p p.* 231, 233.

† *Allen's Theory in Dr. Thomson's Lectures; Ed. Med. Journ. Mizars,* xv, 396, and *Dr. Philip's* Works, Passim.

to what he terms the *erectile* state of the vessels, which distends them with blood, independent of any increased action of the larger arteries. In addition to this note in page 254, vol 4th, "Yet it is evident, "that a mere *relaxation* of tonic power in any set "of vessels, would cause them to swell with blood, "as there is a constant pressure on this fluid, which "would force it in excess to whatever point there was "the least resistance. But in whatever way this is "done, there can be little doubt it is through the "agency of the nervous system;" there is also occasional mention, throughout the pathological remarks of the Journal, of the necessary antecedence of the vitality of the part being affected, before the phenomena of obvious inflammation take place.

Such, then, are some of the written opinions on the intimate nature of the vessels in inflammation, and also on their inflammatory condition being primarily connected with some atonic change in their vital or nervous power; which latter opinions are quite sufficient to shield the doctrine of vascular debility, being the essential constituent of the vessels in inflammation, from the charge of being now either a novel or an injurious hypothesis:—provided it even had not the additional support of a fairer induction from experiment, observation, and analogy, than what the more generally established theory of *increased action* can boast of. There are, besides, many admissions

in the pathological writings of the strict Hunterian adherents, which are as favourable to the atonic theory, as to the one which they have espoused. A good deal of this unconscious ambiguity of language, I conceive, has arisen from the phenomena of disease obtruding themselves on the senses, while the mind was pre-occupied by the ideas of *increased action*, and of *active inflammation;* which abstractions convey with them the associations of increased life and motion, while the successful means of cure or counteraction were such, as seemed to reduce vigour and superabundant vitality. Debility, on the other hand, seemed, *prima facie*, to have so little connection with heat, redness, and all the phenomena of excessive motion in the part or system, that it evaded observation; or, if the exciting causes had, at any time, been acknowledged to have been of a debilitating nature, it was perhaps concluded, that such was not the essential nature of the consequent and constituted disease: as to treat such inflammation on the idea of debility affecting any part of the body, would be to aggravate the commotion, if not to sacrifice the patient. Another circumstance, which has contributed to keep up the supposed necessary therapeutic connection, between the presumption of debility in any part of the system and the administration of tonics and stimulants, is the depleting and antiphlogistic mode of treating many diseases, which former physicians classed under the name of putrid, nervous

and cahectic; but in which a stricter study and attention have since discovered, very frequently, an efficient action identical or analogous to inflammation, and requiring the method of reduction, instead of the former system of heating remedies, tonics, and stimulating food and drinks. The idea of an increased and energetic action was therefore confirmed, if not very often supposed to be demonstrated to exist, from the *post facto* evidence of the beneficial operation of antiphlogistic remedies; because it seemed to hold up the height of inconclusiveness, to make bleeding and purging the necessary cures of a disease, whose primary constituent was debility. Apparent debility of the animal functions in many inflammatory diseases made this symptom to be disregarded in a curative indication; for it was referred to the effect of excessive action in some other department of the system, and its alleviation was observed to follow the degree of reduction, to which the preternatural action of the other part was brought. All these reasonings, and often disjointed sequences of phenomena and results have tended to discard debility, in almost any mode, from the sphere of the proximate causes or inceptive nature of most diseases; and it only became with many, an object of theoretical attention, when the relief of general debility was forced on the care of the practitioner, in the sequelæ or latter stages of diseases. In the invasion or commencement of them, debility in any part of the

chain of morbid phenomena was often neither seen nor suspected; and one undivided and primordial excessive action seemed to claim no consideration, but powerful and quick reduction, which was to be continued until some signs of debility were discovered; if debility itself was not then thought to be first generated in the system.

The doctrine of debility as resulting from the critical and collated analysis, which has been imperfectly detailed in this essay, while it constitutes such an early and necessary link in the chain of inflammation, involves not that consequent mode of treatment, which the term debility would seem to entail. On the contrary, it sanctions the most efficacious *methodus medendi*, while at the same time, it does not lose sight of the fictitious necessity of the measure, nor of the radical feature of the morbid commotion. Inculcating, in active inflammation, the speedy and vigorous reduction of the *vis a tergo* or the vascular momentum, before the dilated vessels are oppressed to paralysis, or to some of the serious results of inflammation; it keeps in view the impaired tension and vitality of the vessels affected, and provides for their vital restitution by gentle and appropriate stimuli, when they can be with safety administered; or when the contraction of the vessels can be attempted, without further exhausting their materia vitæ on a resisting and not yet sufficiently subdued column of blood.

It requires always to be remembered, that the healthy aetion of the debilitated and dilated capillaries is not to be renewed by the mere excitement of their fibres; whether this is produced by extrinsic stimuli, or by what some call the spontaneous and inherent excitement of the larger vessels. The *fons et origo* of the debility being inferred, from what has been advaneed, to depend on the actual diminution, reduction, or suppression of the natural materia vitæ of the part; it follows, that this deficiency cannot essentially be supplied by any excitement of the part, either directly applied, or propagated through the nerves; however mueh, by these means, the remaining or the partially regenerated matter of life may be solicited to the temporary display of its functions. The generation of this vital property or matter, for the eertainty of its physical nature is not yet determined, depends on the supply seereted from the blood, and derived from the non-naturals of animal life. Except, then, any part or set of vessels contain a eertain quantity of this property or substanee, suffieient to control and preserve in healthy tension their eireulating funetions, for some permanent period, premature or inappropriate stimulation only seems to exhaust the remaining materia vitæ, or to expend prejudiciously what is only yet in a nascent state. The beautiful habitude of the sensitive plant is an illustration, how stimulation, too frequently repeated, may seriously impair the vitality of a

vegetable, and may even exhaust it to the total extinction of life. The slow recovery of this essential prineiple accounts for the gradual convalescence, which ensues to inflammations and fevers of comparatively short duration; and the hasty administration of stimulants shows, that to excite is not always to restore strength and tone; as to expend what is accumulated, is quite different from furnishing the supply.

The object then in inflammation, according to the views here assented to and adopted, is to reduce the *vis a tergo*, as near as possible, to an equality with the reduced resistance or the impaired tensiveness of the vessels affected; and sometimes the universal vitality and the blood of the system must be very materially, nay at times precariously, reduced, before this desired equilibrium can be accomplished. This is more particularly requisite, if the local asthenia or irritation has been propagated to the heart, and has produced what is called symptomatic fever—a further sequence in the pathology of inflammation, which has not yet been entered upon, but may, with other febrile phenomena, form the separate consideration of a future essay.

In prosecuting this indication of vascular reduction, a countervailing caution is, not to extend it to that degree, by which a further exhaustion or diminution of the materia vitæ of the inflamed part may be induced, by the supply of the blood becoming too

scanty, impoverished, or too watery. This contingent result, I think, I have noticed in some cases of early practice, where epidemic pneumonia prevailed greatly among crowded bodies of men, and where free and frequent venesection was sometimes followed by a vacillating, soft, and fluttering pulse:—the blood last drawn consisting mostly of serosity, with only a little cupped and floating coagulum of nearly pure fibrin; while the symptoms of inflammation continued not to be materially relieved, and the disease often proved most inveterate, if not fatal.

By too much depletion, the impaired local tension may, therefore, be kept permanently below the par of the system; so that what the injurious excess of the blood may exhaust, its deficiency or poverty may fail altogether to supply. Again, if general bleeding is instituted, even to a very moderate extent, in the advanced stages of congestive inflammation in any of the viscera or cavities, or even where congestion has quickly proceeded to that paralytic dilatation of the vessels, in which the velocity of the blood is very greatly diminished, or is in a semi-stagnant state; the direct result will be, an abstraction of the circulating blood only, which, in these cases, finds its way through the anastomoses of the larger vessels in the neighbourhood of the congested capillary sections, and from which alone the vitality of the affected parts can be restored and supported. The congestion, or what is sometimes

called *l'engorgement* is also increased, in this condition, from the *vis a tergo* being further diminished ; for as the force of the circulating blood becomes lessened in any way, the mass of the congested relatively increases, until the large vessels become retrogradely involved, and the heart itself ceases gradually to act. Deep and most extensive congestion may then exist in the branches of the vena portæ, which no degree of general depletion can relieve, if it does not the more aggravate ; and observation has shown, that even the bleeding from four to six leeches, in such advanced and apoplectic states of congestive and abdominal inflammation, and particularly where early depletion had not been instituted, has produced much weakness of the pulse and depression of the vital functions, without any relief;—but on the contrary, this small bleeding seemed to hasten the dissolution of the patient, who was otherwise of a full habit, and had suffered little previous reduction.

In the first invasion of the West Indian endemic fever among plethoric Europeans, a sudden paralytic congestion of the above kind seems to take place in the cœliac system, before the ardent phenomena are fairly developed. At this period, or what may be termed the stage of atonic collapse or dilatation without increased heat, the abstraction of a very small quantity of blood from the arm, in several of the cases treated or witnessed by me, soon brought on syncope and general enervation, in any posture

of the body. If the practitioner had then sheathed his lancet,—and had remained satisfied, that because no increased action of the vessels existed, there was no necessity for further venesection, which even so far had appeared to aggravate the disorder; he would soon have had proof of the fallacy of such a conclusion. Let the evolution of the heart's reaction be, however, promoted by the tepid bath, and let the congested capillaries recover a little circulating power; he would then find a pulse and a volume of blood, which would withstand the large demands of reduction, even to the extent of 100 to 180 ounces and upwards of blood, in three or four days, without inducing syncope, and with speedy convalescence to the patient; who has, in fact, looked better, and possessed more muscular strength, than before he had lost a tenth part of the quantity, at the invasion of the fever.

In these cases of tropical congestions, it appears that a stage of impaired vitality and tension suddenly takes place, and precedes the period wherein is constituted the real fever; and when that fever has fairly commenced, the congested capillaries have also either regained some degree of circulation, that, according to the remedial measures used, or the strength of the constitution, may gradually pass into the healthy routine; or, as the curative means have been neglected, or other circumstances being unfavourable, semi-stagnation may deteriorate into more complete depriva-

tion of the materia vitæ, and so gangrenous atony, or black vomit, may be the result. Stagnated blood, adhering in cohesive nodules, will melt down in the liquid tide of the circulation, after a slight attrition, as Haller has observed,—which I have once remarked in the circulation of a frog under the microscope.

In the latter stages of inflammation, or when the violence of the symptoms has been subdued, the doctrine above elicited inculcates the greatest precaution in the administration of restoratives, whether of food or medicine; and even insists on a very appropriate application of what are called counter-irritants, as blisters. These, in internal inflammation, are found to aggravate the excitement, if applied in the early stages, before the tension and volume of the blood are reduced. At this period, they seem to excite the distended vessels to contraction, before the pressure and momentum are reduced; and therefore they merely exhaust the already impaired muscular power of the vessel; which is always to be avoided. If their inapplicability in the early stages be not so apparent in any case, as here stated; at least, they always prove more beneficial when vascular reduction has preceded them. In early phrentis and pneumonia, I have seen their application evidently hurtful. The danger of prematurely giving too much, or too stimulant food or medicine, arises, from either the heart being re-excited to its preternatural action, or from the volume of the blood being too quickly increased;

so that the dilated vessels, that were just regaining by degrees their healthy tension, are forced anew into their atonic dilatation, from the volume and momentum of the blood being again augmented. The theoretic point of judicious management is, to promote the real tone or the materia vitæ of the part and vessels, that have lately suffered, without exciting unduly the action of the heart, or overcharging the volume of the blood by nutrition; and so delicately poised are the just reciprocities of these forces in the human economy, that every practitioner must have witnessed from what trifling irregularities, even abstractedly considered, the most serious relapses have ensued. In external inflammation, such as ophthalmia conjunctivæ, the application of the slightest stimulant, even the physical contact of cold water, will sometimes aggravate the early symptoms of pain and redness; while the strongest stimuli, such as vin. opii, or the argent. nit. will hasten, most successfully in the latter stages, the expulsion of the inflammation. In ulcers, accompanied with inflammation, a very short period will render either an emollient, a sedative, or a stimulant the most efficacious, and the easiest application to the patient's feeling;—all depending on the relative states of the capillary tension and relaxation, and the pressure and volume of the *vis a tergo*, provided no new morbid causes of extrinsic irritation have arisen.

In conclusion, then, it appears from what has been shown, as well as from what others have theoretically

and experimentally advanced on the subject, that the term inflammation but comprehends the more obvious and the latter, and not the early sequences of the morbid phenomena, which it should also embrace, and upon which the fully developed symptoms, which generally become the object of treatment, depend. In short, it is expressive of only the latter links in the chain of morbid catenation; and it, perhaps, would aid the generalization of our ideas, if we had a term, not so confined in its import, nor so decidedly significative of heat and increased action, both of which may be absent, in most serious conditions of vascular plenitude and collapse. The term desired should express not only the full blaze of heat, pain, and increased pulsation; but in a general sense, the loss of vital equilibrium between the tension of the vessels, whether arteries or veins,—and the power of the *vis a tergo*, whether implying velocity or volume, or both together. Its consignificatives might denote the species of morbid reciprocities; such as, the extent of the atonic dilatation, and whether it is accompanied with an increased *vis a tergo*, or with a natural momentum of the blood. Such terms might generally comprehend all the varieties of congestion, with, or without, or before fever, and the several states of vascularity, from simple erythism to apoplexy itself. In a therapeutical point of view, bleeding would then be instituted, not because a part is what is called technically inflamed; but

because the vessels of the part or organ are so much distended and enervated, that the removal of the internal and propulsive pressure is a plain indication, whether the action of the heart be increased or not, or even whether the leading arteries exhibit an augmented action or pulsation. The idea of unquestioned debility will then cease to influence the *methodus medendi;* for its existence, from what has been shown, by no means implies the consequent exhibition of nutrients and tonics; on the contrary, the greater the relative extent of this debility may be, the more urgent the demand is for the full and vigorous depletion of the vascular system; especially if the action of the heart is simultaneously augmented and accelerated. The theory of its existence in the materia vitæ of the part, as the prerequisite and associate of inflammation, has, besides, the salutary tendency of keeping in prospect the probable issue and relative contingencies of the disease; so that in attempting to avoid the whirlpool of plethora and increased action, we may take care not to be driven on the rocks of exsanguious exhaustion and general debility of all the functions; when to a temporary failure or reduction of one of the distant springs, would be superadded the threatened destruction of the very fountains of animal life.

Without resuming any extended therapeutical illustration of the above view of inflammation, the action of two remedial agents, opium and mercury, may be

briefly considered; as they have, particularly of late, been a good deal administered in inflammations attended with fever. It is very difficult to obtain any demonstrative proof of the intimate physiological action of these remedies on the animal frame; but on the view, that has been taken of the several vital powers and tissues, and of their reciprocal actions, it is submitted, that these agents may receive a physiological rationale, in much accordance with their known effects in health and disease, and be very confirmatory of the doctrine in question. Mercury, in its constitutional effect, excites all the secretions, promotes capillary heat and circulation, quickens somewhat the action of the heart, reduces, in many cases, adventitious tumors and vascular enlargements, and increases very powerfully the action of the absorbents. These are all effects, with only one exception, in which the capillary tissue and circulation are concerned; and not the great organs or functions of the nervous and sanguineous systems. Without enlarging any further the corroborative support, it may be inferred, that the action of this remedy has principally to do with the corpuscular organization, and, of course, with the materia vitæ of the body; and the effect from it appears to be, an increase of tension and tone in the capillary vessels and blood, or it is a peculiar stimulus of some permanency to the capillary system—which is particularly governed by the muscular power.—Opium, on the other hand, seems primarily to have

little to do with this power or its appropriate tissues; its effects are principally displayed on the mental and nervous systems, exciting or quieting their actions and functions, according to the dose, and the circumstances under which it is administered;—while the only effect which it seems to exert on the capillary system, is through the medium of the nerves. Confining this analysis to its narcotic or sedative effects, it diminishes pain, by suspending or obtunding the sentient transmitting properties of the nerves; it suspends the inordinate effects of volition, and renders one organ or part, for a time, insensible to the disturbance that resides in a distant or neighbouring one. If the dose be increased, even healthy volition is impaired, and the sensorial power becomes wrapt in insensibility; while in all these cases, the action of the capillary system, and the powers of the materia vitæ, may be little or not at all impaired or suspended. But if the dose be still greater, the materia vitæ itself becomes finally involved in the injurious lesion of the other powers; and then complete and fatal suspension of every principle of life may follow. Reasoning then from these physiological data, the action of opium may be referred chiefly and primarily, and to all practical purposes, as affecting the nervous system. Here, then, we have two powerful agents, severally applicable to the two chief powers of animal life; and in considering our indications, according to the above view, it is not difficult to say, when the one or other, or both, may most probably

be beneficial. We also see how febrile movement is incompatible with the physiological action of mercury; as the one generally appears to be a condition of impaired or debilitated materia vitæ with a corresponding capillary atony;—and the other produces, in some permanent degree, an excited state of the same power, with a tensiveness of the capillary vessels and blood.

The administration of opium is better suited to symptomatic fevers, or when topical congestion and inflammation accompany the idiopathic genus, than it is to simple and general fever; because, as its operation is remedial chiefly by suspending or moderating the nervous transmission of morbid and painful sensation from one tissue or organ to another, or even to the brain and heart themselves; so, in general fever without topical lesion, the necessity of cutting off these intercourses is not so apparent, nor does it perhaps exist. Opium, if given alone in these cases, may likely injure more by its stimulating and narcotic effect on the sensorial and nervous systems, than it would otherwise benefit; since the morbid conditions, to which it is more applicable, are not present. Combined, however, with mercury, and given in fever with topical sanguineous disease, it represses the inordinate expenditure of the materia vitæ, by its composing or benumbing effect on the nerves; while the mercury is allowed to act, less undisturbed, with its specific excitation, on the corpuscular fibre and its vital associate. In this manner, the part and system are

brought to an early equilibrium,—the increased action of the absorbents removing the hurtful or superfluous depositions and fluids, the volume of which is hence diminished in the capillaries, while the mercurial stimulus gives these vessels renewed tensiveness and activity;—and, from every probable inference, it moreover quickens the evolution of the materia vitæ from the blood, ingesta, and air.

Before, however, finally concluding this essay, it may be thought requisite to take some notice of one pathognomonic phenomenon, which has always attracted much attention; and upon which great reliance has been placed by many, as a diagnostic sign of the presence of inflammation;—though this part of the subject would more appositely be embraced in any consideration of the nature of fever. The phenomenon is the buffy coat of the blood. Whenever this has appeared on venesection, the practitioner has generally presumed, that he has had a case of inflammation to combat with; and this appearance of the blood has not only been often reckoned a full sanction to the depletion which he has already pursued, but it has also been held as a challenge for him to proceed. The circumstances, however, of fibrin separating from the blood, in states of the body where no inflammatory action was present, as in pregnancy, in scurvy, and in some dropsies; as well as of its not appearing in some cases of violent and even fatal inflammation,

—as has been observed in practice; with its again being observed in the last stages of phthisis, and in some diseases of well-marked general debility, have served to moderate, a good deal, the dependence that medical men were otherwise disposed to pay to its appearance. The causes of its appearance have been involved in much obscurity; and when it was held to be a necessary concomitant of inflammation, the difficulties attending its explanation were rendered more perplexing.

The causes of the buffy coat being intimately involved in the causes of the coagulation itself; a satisfactory rationale of these is necessary to explain this adventitious appearance of the blood. While some, after Hunter, have attributed the coagulation to the vital principle; others, as Thackrah,* have made the loss of vitality the cause of this phenomenon; and others again have contented themselves, with stating the several physical concomitants of the fact:—the chief of which is, the making the extrication of carbonic acid gas an essential condition of the coagulation.† The whole subject being of too extended and detailed a nature for our present inquiry; I shall only state, in what general cases of disease

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* *An Inquiry into the Nature and Properties of the Blood, &c.* By C. T. Thackrah. Lond. 1819. p. 80.

† *Essay on the Blood, &c.* By Charles Scudamore, M. D. F. R. S. Lond. 1824.

I have observed and noted down the buffy coat to be most exhibited. It has been seen chiefly in the early periods of inflammation arising in strong and plethoric constitutions, when there were also heat of skin and a quick full pulse, and more especially in cases of pneumonia and rheumatism. In inflammatory affections of the mucous membranes and of the abdominal viscera, it was less observable; and in some violent inflammations of the stomach and bowels, it has not at all appeared. When there was much nausea or vomiting accompanying any inflammation, it has not been very obvious; and in pneumonia, its quantity seemed more connected with a full and quick pulse, than with a small and contracted state of the circulation; though in this latter case, the condensation and cupping of the coagulum were more perfect. Finally, it seemed very much connected with the shortness of time, that active disease had remained after its supervention to vigorous health, and with the energy of the stomach and chylopoetic viscera during the disease.

Reckoning, then, this buffy appearance to be attended with a slower coagulation of the blood, than that which takes place when drawn in health; and that it is promoted by being taken in a full stream, by rest afterwards, and by being received in deep vessels, of slow conducting power, in regard to caloric; —which circumstances are granted by all observers. And allowing, moreover, with Hunter and some

others, that coagulation depends on the vital principle, (or the muscular materia vitæ which pervades the whole body) and that it depends also on the gradual *loss of it;* or in more correct language, that it depends on what muscular power still adheres to the drawn blood, and its quickness and perfection on the quantity of fibrin and the vitality of the vessels, at the time it is extracted:—the following conclusions cannot be deemed unwarranted. First, the buffy coat depends on the vitality of the blood being diminished, relatively to its extent or volume; which negative condition causes a slower coagulation, and so permits the denser red parts of the blood to subside, before the lighter fibrinous part begins to coagulate;—which coagulation a more vital tone would have anticipated, and so involved both parts in one homogeneous crassamentum. Secondly, the quantity of this fibrinous crust depends on the abundance of fibrin in the blood at the time, in which the vital lesion took place; and that this excess is in proportion to the atony of the capillary secretion of the solid matter of the body, compared with the vigor and absorption in the chylopoetic functions. Thirdly, the thickness and condensation of the buffy coat are in proportion to the quantity of fibrin in the blood, and to its more perfect separation from the clot and serum; while the cupping and the inverted edge depend on the softness of the subjacent clot, and on the more or less complete separation of the fibrin; by the degrees

of which, their mutual cohesion is lessened, and so retraction takes place to the surface of purer fibrin. Viewed in this light, the buffy appearance has no absolute connection with inflammation; it is more a criterion of the suspension of fibrinous secretion, or of an excess of fibrin in the blood, from the supply surpassing the natural demand; and above all, it cannot be held as a mark of increased tone and real vitality. Its appearance in the first cup, and less or none at all in the second or third, seems to arise from the first drawn blood being not so *vitalized*, from its remaining longer in the atonic capillaries, as the rest which comes more directly from the heart,—the chief seat of the materia vitæ or muscular power. In healthy pregnancy, there is always an excess of fibrin; no doubt to supply the uterine demand, at the expence very often of the muscular accretion of the pregnant body. In phthisis, the stomach and primæ vitæ are often in tolerable, and sometimes in good assimilating function; while the blood must necessarily be kept down in general volume, from the diminishing capacity of the lungs, by the extent of which the aortic capacity must be regulated; therefore fibrinous blood will generally appear in this disease. As acute rheumatic fever affects the very solids, which in health take up almost the whole supply of fibrin, a very remarkable excess of it is to be expected in this disease; while inflammation or lesions, which affect the stomach and assimilating organs, exhibit less and

sometimes none of this fibrinous coat,—as the laboratory where the fibrin is formed is neutralized or disordered. Lastly, from a complete loss of vitality in the blood, as by lightning, poisons, especially animal ones, and fatal blows on the stomach, or even in some very asthenic diseases, coagulation will not take place, but the blood will remain fluid, dark, or greenish and dissolved; and no fibrin will make its appearance.

THE END.

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CORRIGENDA.

Page 11, *line* 2, *for* patholgy *read* pathology.
14, — 23, *for* tone *read* term.
23, — 19, *for* cæliac *read* cœliac.
34, — 3, *for* preception *read* perception.
37, — 15, *for* and the viscidity *read* and directly as the viscidity.
45, — 13, *for* Thompson *read* Thomson.
76, — 8, *for* or *read* nor
124, — 1, *after* dilatation *read* of a pulsatile nature.
135, - 28, *after* always *read* to.
140, — 5, *after* blood *read* in.

A few French words, in the first 14 pages, want the accent.